

NPS ARCHIVE
1966
BLATT, R.

A MODEL FOR AUTOMATION OF
PERSONNEL ASSIGNMENT

RUSSEL NEAL BLATT
AND
DUDLEY E. CASS

LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIF. 93940

**DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CA 93943-5101**

A MODEL FOR AUTOMATION
OF PERSONNEL ASSIGNMENT

by

Russel Neal Blatt
Lieutenant, United States Navy
B.S., United States Naval Academy, 1958

and

Dudley E. Cass
Lieutenant, United States Navy
B.S., University of Washington, 1961

Submitted in partial fulfillment
for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

UNITED STATES NAVAL POSTGRADUATE SCHOOL
October 1966

ABSTRACT

This thesis demonstrates the feasibility of computerized assignment of Naval enlisted personnel to fleet units. A model is constructed for determining the utility of each man for each possible ship assignment. Then various methods of assignment are investigated to find one which maximizes the summed utilities of assignment. To illustrate its capabilities, the model is then applied to several sample sets of men and ships. The authors conclude that a model of this type should be implemented in the Navy's personnel distribution system.

TABLE OF CONTENTS

Section	Page
1. Introduction	9
2. Model	12
3. Summary and Conclusions	45
4. Bibliography	49
Appendix A. Description of Personnel Assignment Deck	51
Appendix B. Codes Used in Assignment Deck	56
Appendix C. Data Input for AUTAM	59
Appendix D. AUTAM Computer Program	67
Appendix E. FORTRAN Listing of Alternate Assignment Methods	102
Appendix F. Sample AUTAM Printout	107

LIST OF TABLES

Table	Page
1. Effect of Modification of (POB-6)/(EDP) Ratio	17
2. Designation of (POB-6)/(EDP) Ratio for Each Rate	19
3. Illustrative Indifference Comparison	22
4. Sample Data for Comparison of Assignments	25
5. Weights Determined by Iteration Process	27
6. Utility Matrix for Assignment	30
7. Group and Subgroup Average Marginal Utilities	36
8. Distribution Comparison of Five Methods of Assignment of 50 BM's	39
9. Qualitative Parameters for Comparison of Five Methods of Assignment of 50 BM's	41

LIST OF ILLUSTRATIONS

Figure	Page
1. Feed-Back Process of Weight Evolution	28

1. Introduction.

The ultimate objective of all administrative systems concerned with the movement of personnel is to maximize their utilization in the fleet. The basic aim of all personnel support systems, such as selection, classification, and training, is to ensure full utilization of personnel if at all feasible. The medium through which these ends must be attained is the fleet personnel assignment system.[3]

Under the present system of fleet personnel assignment, BUPERS assigns about twenty types of specially qualified people to fleet units. The remaining assignments are made by the Type Command Representatives (TYCOMREP) at the Enlisted Personnel Distribution Offices (EPDO). The TYCOMREP personnel assigners make their assignments on a one-at-a-time basis, using their best judgment, various thumb rules, and a number of policy and concept guidelines. Some of the man-related parameters which must be considered include personal preferences, experience, training, number of dependents, obligated service remaining, and present location of the man and his dependents. These parameters must be matched in proper sequence with the parameters descriptive of the units to which the man could be assigned. Some ship-related parameters are operating schedules, location, homeport, status of personnel requirements, and requirements unique to the particular unit. It can be seen that the task of the personnel assigner in the present system is a complex and difficult one.[12]

Since the days of "wooden ships and iron men," the Navy has grown to such magnitude in physical size, number of different types of operating units, and different skills required to operate them, that manual means of assignment are no longer acceptable. Even on a one-at-a-time basis, it would be difficult and very time consuming for an assigner to consider all pertinent parameters for each man in an objective and consistent manner. It is almost impossible to consider the array of all possible assignments, given a group of men to assign to a number of ships. But, to make the optimal set of assignments, the array of all possible assignments must be considered.

Given a number of units and a group of men to assign, it is assumed that the desirability of each possible assignment can be represented by an ordinal utility value which is useful in relating that assignment to all other possible assignments. Then, by "optimal" assignment, the available men are assigned to units in a manner such that the summed utility of all assignments is maximized. Of course, the utility of an assignment must consider both the utility of the man for the ship and the utility of the ship for the man. Maximum utilization cannot be realized unless both the ship's needs and the man's needs are considered in every case.

The determination of the utility of an assignment is a particularly difficult problem for the Navy. It might also be considered a unique problem in that the operating and deployment schedules of fleet units cause the utility

of the assignment of a man to a ship to be time-dependent; i.e., the benefits a ship can derive from the assignment of any man is directly dependent upon that ship's state of operation. For example, all other things being equal, a man may be more valuable to a ship preparing for deployment than to a ship returning from deployment, or going into the shipyard for overhaul. Some time-independent parameters affecting the utility of an assignment will be discussed later in the paper.

The discussion thus far has indicated that the complexity and number of operations required in determining the utility of each possible assignment and then finding the optimal set of assignments is beyond the capability of manual methods. Therefore, the use of computer techniques is proposed as a method of solution to the assignment problem.

In a properly structured computerized assignment model, all parameters involved in all possible assignments can be considered in making the "optimal" set of assignments. Thorpe and Conner have postulated that an acceptable computerized assignment model has to meet three basic requirements: first, it has to determine for which assignments a man is eligible; second, it has to evaluate the utility value or "return" for each man in each billet for which he is eligible; finally, the assignment model has to select the set of assignments for which the total value of all men available for assignment in all vacant billets is maximized. [12]

These requirements constitute the basis for AUTAM (AUTomated Assignment Model), which the authors have developed and analyzed as a demonstration of the feasibility and effectiveness of computerized assignment.

2. Model.

As the name implies, AUTAM is a computerized model for assignment of personnel on the basis of utility. AUTAM is not just a theoretical exercise for computer fanatics. It is, in fact, a useful assignment model which can be implemented (with few changes) at any level of personnel administration.

In order to insure understanding at all levels, the model was kept as simple as possible. For purposes of assignment, an imaginary Type Command consisting of sixteen ships was considered. Within this TYCOM only three ratings were used: Boatswain's Mates, Quartermasters, and Signalmen. These rates were picked because they are not sensitive to Naval Enlisted Classification codes (NEC's) and thus allowed a more compact program.

As previously stated, certain man and ship parameters must be matched in proper sequence in order to determine a utility of assignment of each man for each ship. The number of parameters used in this model was kept to a minimum for the sake of simplicity. Significant omissions from the model are the man's NEC, performance evaluation, and choice of ship type. However, it was felt that the inclusion of too many parameters would only add unnecessary complexity to the model. A few representative parameters

were arbitrarily chosen to show how they might be adopted to the program. Once the reader is familiar with the processing of the model, AUTAM can easily be expanded to include any parameters that might be required. The parameters considered in this model were:

- Man-related:
- (1) Rating and pay grade.
 - (2) Take-up date (predicted date of reporting on board).
 - (3) Homeport preferences.
 - (4) EAOS (expiration of active obligated service).
- Ship-related:
- (5) POB-6 (predicted on board count six months from now for a given rate and pay grade).
 - (6) EDP (enlisted distribution plan - number of personnel required).
 - (7) Homeport.
 - (8) Overseas deployment date.
 - (9) Return date from deployment.

The man-related parameters used in this model are available on the punched-card standard-format assignment deck for each man.^[1] Appendix A gives a detailed description of all the man-related data that can be found on these cards. The ship-related information is readily available at all personnel distribution centers.

Having chosen the desired parameters, it was necessary to derive the assignment variables as functions of these parameters. This was accomplished by performing the

man-ship matching operation which was mentioned earlier.

In particular, the following relationships were examined:

- (1) Man's rating and pay grade vs. ship's requirements and POB-6 in that rating and pay grade, pay grade above and/or below.
- (2) Man's take-up date vs. ship deployment dates.
- (3) Man's homeport preferences vs. ship's homeport.
- (4) EAOS date vs. ship deployment dates.

Although the use of these variables in the model reflects the judgment of the authors, the model is not restricted to these expressed and implied judgments. The assignment "ground rules" used by any assigner or group of assigners can be applied to this model with equal effectiveness. To show how this might be done, the "assignment policy" of this model is as follows:

All other things being equal between men and/or ships, it is desirable to accomplish the following:

- (1) "fill", or even "overfill" slightly, a ship preparing to deploy, in order to insure that the ship has sufficient manpower to meet its operational commitments and allow for normal manpower attrition. This policy also reduces the cost of transporting additional men overseas to the ship.

- (2) insure that an assigned man has sufficient obligated service to complete the ship's next deployment.
- (3) assign a man in accordance with his homeport preference.
- (4) assign a man to the ship which has the smallest (POB-6)/(EDP) ratio for the rating concerned. This is the most important factor in assignment. In addition, the ratio of (POB-6)/(EDP) for the pay grade above and/or below the subject man should be considered. A man in any specific pay grade has positive utility to the ship which is short of men in the pay grade above and/or the pay grade below.

Using these criteria, the assignment variable, W_{ijk} , was computed for the assignment of the i^{th} man to the j^{th} ship as follows:

- (1) W_{ij1} - Is take-up before deployment? (Parameters 2 and 8)¹
 - No - 0
 - Yes - 1
 - Yes and ≤ 3 months before deployment - 2²

¹The parentheses indicate which parameters are compared to determine the answer to the question. See page 13 for parameter list.

²The values assigned for each answer are strictly arbitrary. They reflect only ordinality of preference, not relative magnitude of preference.

- (2) W_{ij2} - Is take-up during deployment? (Parameters 2, 8, and 9)

No - 0

Yes - 1

- (3) W_{ij3} - Is EAOS after return date? (Parameters 4 and 9)

No - 0

Yes - 1

- (4) W_{ij4} - Is ship homeport one of man's preferences? (Parameters 3 and 7)

No - 0

2nd choice - 1

1st choice - 2

- (5) W_{ijk} ($k = 5, \dots, 11$) takes into account the POB-6 and EDP information. (Parameters 1, 5, and 6). For the i^{th} man's rating and pay grade, the model computes for the j^{th} ship:

$$\left(\frac{\text{POB-6} + .1}{\text{EDP} + .1} \right) j$$

For the i^{th} man's rating and pay grade above and below, the following is computed for the j^{th} ship:

$$\text{Pay grade above: } \left(\frac{P + P_A + .1}{E + E_A + .1} \right) j$$

$$\text{Pay grade below: } \left(\frac{P + P_B + .1}{E + E_B + .1} \right) j$$

TABLE 1
Effect of Modification of (POB-6)/(EDP) Ratio

SHIP PARAMETER	A	B	C	D	E	F	G
POB	1	10	0	0	1	2	2
EDP	2	20	1	2	0	0	2
POB/EDP	$\frac{1}{2}=0.5$	$\frac{10}{20}=0.5$	$\frac{0}{1}=0$	$\frac{0}{2}=0$	$\frac{1}{0}=\infty$	$\frac{2}{0}=\infty$	$\frac{2}{2}=1$
$\frac{POB+1}{EDP+1}$	$\frac{1.1}{2.1}=.525$	$\frac{10.1}{20.1}=.503$	$\frac{0.1}{1.1}=.091$	$\frac{0.1}{2.1}=.048$	$\frac{1.1}{.1}=11$	$\frac{2.1}{.1}=21$	$\frac{2.1}{2.1}=1$

where $P = POB-6$

$E = EDP$

SUBSCRIPT NOTATION:

A = pay grade above

B = pay grade below

none = pay grade of interest

It is noted that a constant value of 0.1 is added to both the numerator and denominator in the above ratios. The 0.1 in the denominator prevents division by zero and the same constant in the numerator allows comparisons in cases where the POB-6 is zero. Although the addition of this constant does not alter the ordinal utility of an assignment, it does bias the assignment in favor of the ship with the larger EDP. Table 1 gives examples of how the addition of the 0.1 effects the $(POB-6)/(EDP)$ ratio. (In following these examples, the reader is reminded that a low $(POB-6)/(EDP)$ ratio corresponds to a high utility.)

First, comparing ships E and F in the table, it is obvious that $(POB-6)/(EDP)$ ratios cannot be computed because both ships have EDP's equal to zero. However, adding the 0.1 constant allows ratios to be determined as shown in row 4. In this case, ship F is overfilled by two men and has the higher ratio. Therefore, ship E has the higher utility and will be favored for the assignment. A comparison of ships C and D demonstrates the case where both ships have a POB-6 equal to zero. Since the ratio is again indiscriminate, the addition of the constant is needed to allow the ratios to be formed as shown in row 4.

Ship D is favored.

One final example is given to indicate how the addition of the 0.1 constant tends to bias the ratio in favor of the larger ship. In Table 1, ships A and B both have the same ratio of 0.5. However, after the addition of the constant, ship B has the lower ratio and is favored for assignment. Valid arguments can be presented both for and against this procedure. Therefore, it is hypothesized in this model that in those cases where the ratios are equal, it is better to assign to the ship needing the most number of men. To reverse this hypothesis, a small constant could be subtracted with a slight arithmetic modification. Before leaving the (POB-6)/(EDP) ratio, two more facts should be mentioned: (1) AUTAM was arbitrarily set up to compute the (POB-6)/(EDP) ratio for the i^{th} man's pay grade, pay grade above and/or pay grade below, in that order. (2) The W_{ijk} ($k = 5,6,7,8,9,10,11$) elements are designated in the model as follows:

TABLE 2

Designation of (POB-6)/(EDP) Ratio for Each Rate

i^{th} Man's Rate	Rate For Which W_{ijk} is Computed				
	CP0	PO1	PO2	PO3	STKR
CP0	W_{ij5}	W_{ij6}			
PO1	W_{ij8}	W_{ij7}	W_{ij9}		
PO2		W_{ij8}	W_{ij7}	W_{ij9}	
PO3			W_{ij8}	W_{ij7}	W_{ij9}
STKR				W_{ij11}	W_{ij10}

The significance of Table 2 may not be clear at this point, but it will be useful for reference during the discussion involving weighting factors for these variables.

Now that the variables have all been defined, it can be shown how these variables can be used to determine the utility of assignment of the i^{th} man to the j^{th} ship.

In AUTAM, this utility is

$$u_{ij} = a_0 + \sum_{k=1}^{11} a_k W_{ijk} \quad (1)$$

where a_0 is an arbitrary intercept point (10 in this model) and a_k is the weight assigned to each variable, W_{ijk} . The assumption of linearity was assumed in equation (1) for ease of computation. It was also considered that first order approximations were sufficiently accurate for this model.

The determination of the weight (a_k) of each variable is, obviously, a crucial part of the model. The concept of an effective assignment model is based on the assumption that proper weights can be found such that the generated utility of assignment, u_{ij} , reflects accurately the assignment policy desired. Since the assignment policy is based on the judgment of personnel administrators, the assignment weights must likewise be generated through repeated subjective judgments which are consistent with the policy set forth. As an illustration, it will now be shown how the weights used in this paper were determined.

Of all the variables considered in this model, the (POB-6)/(EDP) ratio is the most important. Therefore, it was used as the reference variable for determining the first rough weights. The reader is referred to Table 2 to see how the (POB-6)/(EDP) ratio for each rate is designated in the model. From this it can be seen that a good starting point might be the a_5 and a_6 coefficients. These coefficients represent, respectively, the weight assigned to the (POB-6)/(EDP) ratio for a Chief Petty Officer and the weight assigned to a Chief Petty Officer who might be utilized in a First Class Petty Officer's billet. This assumes that, other things being equal, a CPO has a greater utility on a ship which is short of PO1's than a ship which is over-filled with PO1's. This assumption was taken into account in the derivation of the W_{ijk} vectors for the pay grade above and the pay grade below. The mathematical formulation of these vectors was shown earlier.

First, a_5 was arbitrarily set equal to -5. (The negative sign is necessary to counterbalance the fact that an increase in numerical value of W_{ij5} causes a decrease in u_{ij} .) Then it was assumed that there were two ships, 1 and 2, to which the i^{th} man could be assigned. By use of an indifference comparison, similar to that used in the economic study of consumer choice, [5] values were found for W_{ij5} and W_{ij6} which caused the authors to be indifferent between assignment to either Ship 1 or Ship 2. The following is an example of this procedure:

TABLE 3
Illustrative Indifference Comparison

Trial	Ship (j)	W_{ij5}	W_{ij6}	Preferred Assignment
1	1	.7	.7	Ship 1
	2	.9	.9	
2	1	.7	.7	Ship 1
	2	.9	.5	
3	1	.7	.7	Indifferent
	2	.9	.3	

On the first trial in Table 3, the W_{ijk} values were picked arbitrarily. Since Ship 1 has a lower (POB-6)/(EDP) ratio for both CPO and PO1, it has a higher utility of assignment and is preferred for assignment of a CPO. In the second trial, the W_{ij6} value for Ship 2 was reduced to .5. However, the authors felt that Ship 1 still had preference for assignment of CPO. In the third trial, the greatly reduced ratio for PO1's on Ship 2 caused the authors to become indecisive as to which ship should be assigned an additional Chief Petty Officer. Therefore, this was the indifference point for these two variables, W_{ij5} and W_{ij6} . It should be noted that this is not a unique set of values.

Using the values from the third trial and $a_5 = -5$, the utility of Ship 1 was set equal to the utility of Ship 2 and solved for a_6 :

$$u_{i1} = u_{i2}$$

$$a_5^{W_{i15}} + a_6^{W_{i16}} = a_5^{W_{i25}} + a_6^{W_{i26}}$$

$$(-5)(.7) + a_6(.7) = -5(.9) + a_6(.3)$$

$$a_6 = -2.5$$

With W_{i15} as reference and a_5 still equal to -5, the values of a_1 , a_2 , a_3 and a_4 were determined by the same method. The results were: $a_1 = 0.5$, $a_2 = -1$, $a_3 = 1$, $a_4 = 0.5$. Since a_7 , a_8 , and a_9 apply only to rated Petty Officers (P01, P02, and P03) and a_{10} and a_{11} apply only to Strikers, they were determined separately.¹ In this case a_7 was set equal to -5 and a_8 and a_9 were found to be -5 and -3.5 respectively. Similarly a_{10} was set equal to -5 and a_{11} was found to be -3.5. Thus far, the values obtained were:

$a_0 = 10$	$a_4 = 0.5$	$a_8 = -5$
$a_1 = 0.5$	$a_5 = -5$	$a_9 = -3.5$
$a_2 = -1$	$a_6 = -2.5$	$a_{10} = -5$
$a_3 = 1$	$a_7 = -5$	$a_{11} = -3.5$

For the purpose of allowing the utilities between different pay grades to be easily compared, the a_k ($k = 5, \dots, 11$) were rescaled such that

$$\sum_{k=5}^6 a_k^{W_{ijk}} = \sum_{k=7}^9 a_k^{W_{ijk}} = \sum_{k=10}^{11} a_k^{W_{ijk}}$$

¹The reader is referred to Table 2 to verify this statement.

This was done by first assuming a utility range, $0 \leq u_{ij} \leq 10$. Since $0 \leq w_{ijk} \leq 2$ for all conceivable cases, a_k was scaled such that

$$\sum_{k=5}^6 a_k = \sum_{k=7}^9 a_k = \sum_{k=10}^{11} a_k = -5$$

On this basis the following revised values were obtained:

$$\begin{array}{lll} a_5 = -3.3 & a_7 = -1.9 & a_{10} = -2.9 \\ a_6 = -1.7 & a_8 = -1.9 & a_{11} = -2.1 \\ & a_9 = -1.3 & \end{array}$$

Recalling that $a_5 = -5$ was used as a reference to determine a_k ($k = 1, 2, 3, 4$), it became necessary to rescale these four coefficients in order to maintain their same relationship with a_5 . Doing this: $a_1 = .3$, $a_2 = -.7$, $a_3 = .7$, $a_4 = .3$.

The procedure discussed above could be used to determine the first approximate weights for any number of variables. However, these are only approximations and must be checked by using them in the model and analyzing the results to see if the desired policy guidelines are being followed.

In this paper the initial weights were refined as follows: Using the a_k values determined above, assignment of 40 men to 16 ships was accomplished utilizing the program shown in Appendix D. This gave a sample of 640 assignments.

TABLE 4
Sample Data for Comparison of Assignments

Man i	Ship j	$W_{ijk}, k = :$											
		1	2	3	4	5	6	7	8	9	10	11	u_{ij}
1	10	0	1	1	0	0	0	.05	.09	1.48	0	0	8.86
2	13	2	0	1	0	0	0	.05	1.00	.52	0	0	8.83
34	13	1	0	1	1	0	0	.26	1.00	.30	0	0	8.62 8.5
22	11	0	1	1	0	0	0	.05	.52	1.00	0	0	8.47 8.6
2	16	0	1	1	0	0	0	.05	1.00	.09	0	0	8.39
36	16	2	0	1	0	0	0	.51	.51	1.00	0	0	8.31
1	4	0	0	1	0	0	0	.05	1.00	.52	0	0	8.29 8.1
21	2	0	1	1	0	0	0	.05	.52	1.49	0	0	8.02 8.2
34	8	1	0	1	0	0	0	.63	.80	.50	0	0	7.65
35	11	0	0	1	0	0	0	.50	.83	.54	0	0	7.57
33	13	1	0	1	1	0	0	.51	1.20	.44	0	0	7.56 7.6

Since those assignments with extremely high or low utility values contribute little to the refinement process, they were eliminated from the sample. Also those assignments having duplicate W vectors were eliminated. This reduced the original sample of 640 assignments to a subsample of 85 assignments. The assignment program of Appendix D was modified to give an output (on standard punched cards) of the assignment identification (number of the man and ship), the W vector describing this assignment, and the computed utility of this assignment. These punched cards were then arranged in order of descending utility value, sorted by rate group, and printed as shown in Table 4. The assignments were then compared, two at a time, to see if the assignment with the higher computed utility value was in fact preferred to the assignment with the lower utility value. Where this was not the case, the utility values were changed to reflect the disagreement with the computed utility ranking. For example, in Table 4, it was decided assignment (22,11) should have a higher utility value than assignment (34,13) because Ship 11 was lower in the rate ($W_{22,11,7}$), and rate above ($W_{22,11,8}$) comparisons. This outweighed the fact that for assignment (34,13), the man would be picked up before deployment ($W_{34,13,1}$), would receive his second choice homeport ($W_{34,13,4}$), and would alleviate a shortage in the rate below ($W_{34,13,9}$). When all assignments had been compared, the corrected utility values and the original values of the W_{ijk} variable were

TABLE 5
Weights Determined by Iteration Process

Iter. No.	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	u_{ij} changes
1	.30	-.70	.70	.30	-3.30	-1.70	-1.90	-1.90	-1.30	-2.90	-2.10	37
2	.29	-.60	.79	.32	-3.25	-1.65	-2.03	-1.81	-1.11	-2.90	-1.95	33
3	.26	-.53	.73	.30	-3.27	-1.57	-2.05	-1.77	-1.03	-3.03	-1.72	37
4	.28	-.40	.79	.35	-3.37	-1.49	-2.11	-1.80	-0.97	-3.08	-1.70	20
5	.27	-.30	.80	.33	-3.52	-1.57	-2.25	-1.92	-0.92	-3.15	-1.83	18
6	.26	-.30	.95	.33	-3.50	-1.58	-2.26	-1.94	-0.87	-3.14	-1.82	5
7	.26	-.30	1.41	.33	-3.50	-1.59	-2.27	-1.94	-0.88	-3.14	-1.82	0

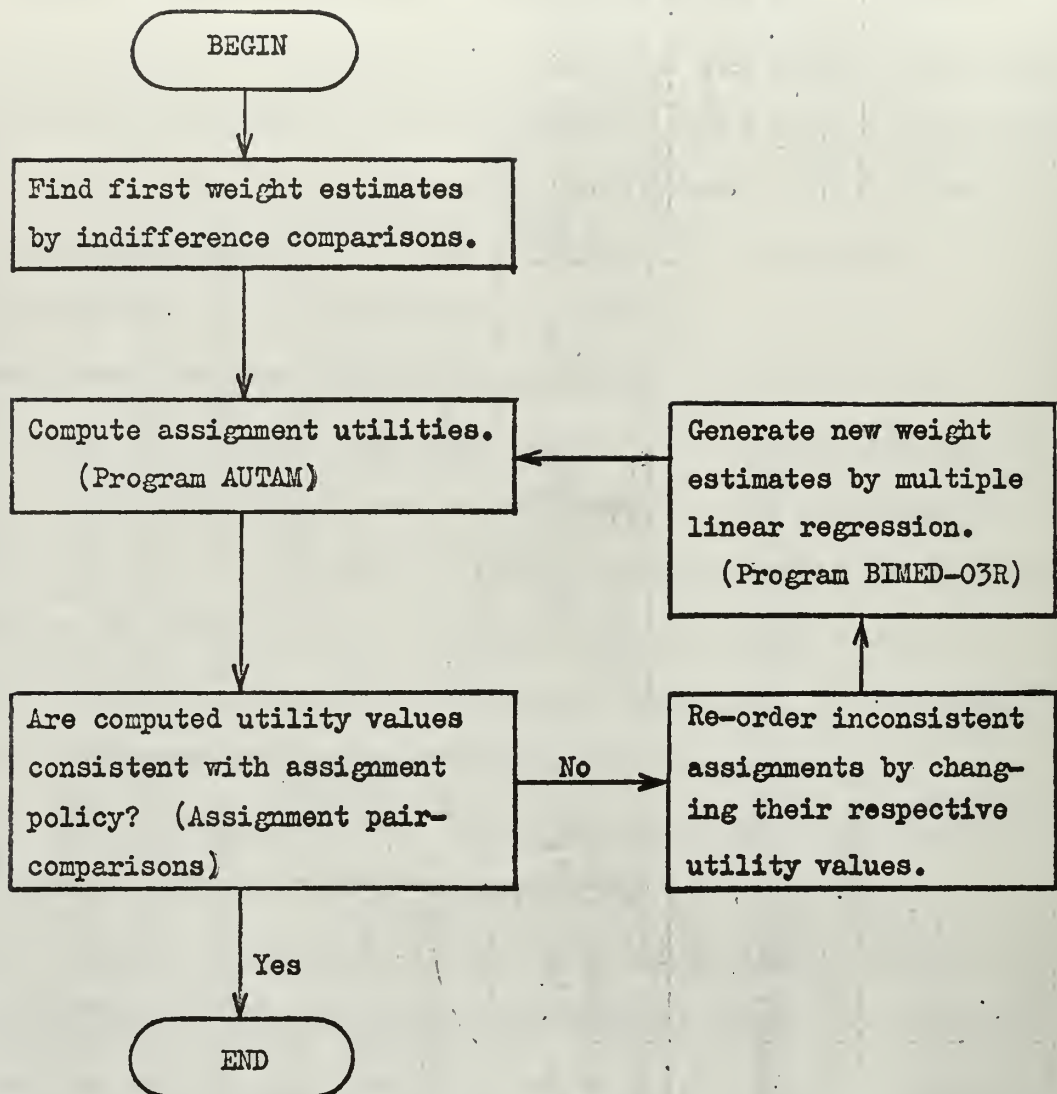


Figure 1
Feed-Back Process of Weight Evolution

then used as data input to a multiple linear regression computer program, [2] generating new weights, a_k , as the regression coefficients of the linear regression. This process was repeated until the weights obtained resulted in satisfactory assignments. For this paper, the weights were considered satisfactory when the number of utility values changed were less than 5% of the total number in the representative sample. The evolution of the weights which satisfactorily represented the "assignment policy" of the authors is shown in Table 5. Seven iterations were required. Note that 37 of 85 utility values were changed in the first iteration; none were changed in the final run.

The evolution as described, may be thought of as a "feedback" process represented as a flow diagram in Fig. 1. It is evident that much of this process depends on the judgment of the authors. However, it cannot be too strongly emphasized that the same process can be carried out by any assigner, or group of assigners, using policy guidelines determined by proper authority. [17]

After the weights of all the variables have been determined, the utility of assignment of the i^{th} man to the j^{th} ship can be found by using equation (1). All the utility values can then be arranged in an $(n \times m)$ array for the assignment of n men to m ships. Having set up the array as in Table 6, the objective is to assign the men such that the sum of the utilities is maximized. It is obvious that assignments must be made sequentially because the u_{ij} values

must be recomputed after each assignment to reflect corrected POB-6 figures; i.e., the assignment of a BM1 to a ship lowers the utility of assignment of any remaining BM1, BMC, or BM2 to be considered for that same ship.

TABLE 6
Utility Matrix for Assignment

MAN	SHIP NUMBER			
	1	2	3	4
MUNYON A BM1	8.6	6.8	9.0	10.0
MULTUNAS BM2	7.3	5.4	8.3	9.4
STEVENSON BM2	7.0	5.4	8.1	10.2
WHITTLET BM2	7.3	5.4	8.3	9.4
WENGER R BM2	7.3	5.9	9.3	9.4
ANDERSON BM3	6.5	3.1	8.6	5.9
BRAINARD BM3	6.5	3.6	8.8	6.6
SANNICOL BM3	6.5	2.6	8.6	5.9
TRUJILLO BM3	6.5	3.6	8.6	6.4
COLLINS BM3	7.0	2.6	9.6	5.9
GARRIDO QM1	6.7	2.8	7.3	8.7

After the utility array has been determined, the method of assignment from this array will affect whether or not maximum utility is achieved. The classic linear programming simplex solution to the personnel assignment problem was not used because: (1) the ships have no explicit "quotas" which must be filled or cannot be

exceeded, and (2) the men do not have constant utility values for all ships.

Several other standard methods exist for obtaining exact solutions to the classical assignment problem. However, the problem treated in this paper does not readily lend itself to these methods. Therefore, the authors considered methods of assignment which would:

- (1) at least approximate a maximum solution.
- (2) minimize computer run time.

On this basis, the following five alternative methods of assignment were investigated.

(1) Row Maximum

This was the simplest method investigated and was chosen because it was believed to most nearly simulate the manual assignment method. The i^{th} man is assigned to the j^{th} ship where i, j are determined by

$$\max_j u_{ij}, i = 1, 2, 3, \dots, n.$$

This method looks at the first man and assigns him to the ship with the highest utility. This man is deleted from the array, the remaining affected u_{ij} 's are recomputed, and the next man is assigned in the same manner. This process is continued until all men are assigned. Using this method in the array of Table 6, MUNYON would be assigned to Ship 4, the u_{i4} for the remaining BM's recomputed, then MULTUNAS would be assigned to the ship with the highest utility value.

Appendix D shows the basic assignment program used for all five methods considered in this paper. The application of a separate subroutine for each method allows the different methods to be accomplished by the computer. In this case (Row Maximum), the subroutine in Part 1 of Appendix E is used.

(2) Array Maximum

This method is one step of complexity above the Row Maximum method. Instead of looking at only one row of the array and picking the maximum, this method makes the assignment of the p^{th} man to the q^{th} ship such that

$$u_{pq} = \max_i \max_j u_{ij}$$

This method makes the assignment having the highest utility in the array. The assigned man is deleted from the array, all the affected u_{ij} 's are recomputed, and the procedure is repeated until all men are assigned. In the array in Table 6, STEVENSON BM2 would be the first man assigned, and would be assigned to Ship 4.

For computer purposes, the subroutine in Part 2 of Appendix E is used for this method.

(3) Row-Column Maximum

This method was investigated because of the possible savings in computer time. Rather than recompute the affected u_{ij} after each assignment, this method assigns up to m men before recomputing the affected u_{ij} . The p^{th} man is assigned to the q^{th} ship if

$$u_{pq} = \max_i u_{iq} = \max_j u_{pj}$$

In this method, the first column (first ship) is looked at to see if the maximum in that column is also the maximum utility in it's row. If it is, that assignment is made and the second column is checked. If there is no row and column maximum, no assignment is made and the program goes to the next column. After all columns (ships) are checked, and the resulting assignments are made, the utilities are recomputed, and the process is reiterated until all men are assigned. In the array of Table 6, columns 1 and 2 have no row-column maximum. However, columns 3 and 4 do, and COLLINS would be assigned to Ship 3 and STEVENSON to Ship 4. Then the utilities would be recomputed before starting over.

The subroutine in Part 3 of Appendix E is used to perform this operation on the computer.

(4) Modified VAM

Vogel's Approximation Method (VAM) is a natural choice as a possible solution to this type of assignment model because it assigns sequentially and provides a solution that is usually quite close to optimum. [11] It is also a convenient method to use because it presents little programming difficulty, requires few iterative operations, and utilizes minimum-time arithmetic operations.

The logic supporting this method is that a near maximum solution should be obtained if, at each step, the man is

assigned who will incur the greatest loss of utility if he is assigned to the ship having the second highest utility for him.

The VAM method, as modified for this paper, computes in each row of the utility array the difference between the maximum utility and the next highest utility. After this has been determined for all rows, assignment is made to the maximum utility in the row with the maximum difference. The affected utilities of the remaining men are recomputed and the above process is repeated until all men are assigned. As an example, applying this method to the utility array in Table 6, COLLINS would be assigned to Ship 3.

Appendix D contains the subroutine which pertains to this method of assignment.

(5) Decision Index

This method of assigning personnel has been proposed for use by the Air Force and is included for comparison. [16] It is based on the assumption that only one man will be assigned to any one job (ship). Ward has shown that the expected value of the sum of all remaining assignments is maximized by making the assignment (p, q) where DI_{pq} is the maximum value of the Decision Index array. [15]

$$DI_{pq} = mu_{pq} - \sum_{j=1}^m u_{pj} - \sum_{i=1}^n u_{iq} \quad (2)$$

where m = number of ships

n = number of men to be assigned

u_{pq} = utility of assignment of p^{th}
man to q^{th} ship

The Decision Index array is computed by use of equation (2). The assignment is made to the maximum DI, the utility array is recomputed, DI array is recomputed, and the procedure is repeated until all assignments are made. As an example of this process, the first row of the Decision Index array would be computed from Table 6 as follows:

$$DI_{11} = 4(8.6) - 34.4 - 77.2 = -77.2$$

$$DI_{12} = 4(6.8) - 34.4 - 47.2 = -54.4$$

$$DI_{13} = 4(9.0) - 34.4 - 94.5 = -92.9$$

$$DI_{14} = 4(10.0) - 34.4 - 87.8 = -82.2$$

The entire array must be computed, in the manner illustrated, before any assignments can be made. If DI_{12} is the maximum of the array, then the first man would be assigned to Ship 2.

This assignment method is accomplished by use of the subroutine in Part 4 of Appendix E.

In order to obtain data for the analysis of the five methods of assignment, each method was applied to the model, utilizing the weighting factors found earlier in the paper.

First, each method was used to assign the same sample of 50 men to 16 ships. This sample, designated Group I, was composed of 50 Boatswain's Mates of all pay grades.

TABLE 7
Group and Subgroup Average Marginal Utilities

Group	Subgroup	No. Men	Average Marginal Utility				
			ROW	ARRAY	ROW-COLUMN	VAM	D. I..
I	-	50	7.602	7.608	7.465	7.727*	7.103
II	-	50	7.584	7.526	7.592	7.635*	6.344
	A ₁	25	7.666	7.607	7.647	7.686*	6.743
	A ₂	25	7.529	7.577	7.574	7.554	6.148
	Over-All Ave. Marg. Utility		7.597	7.592	7.610	7.620*	6.445
	B ₁	6	7.943	7.943	7.943	8.050*	7.822
	B ₂	4	8.114	7.953	8.114	8.114*	6.915
	B ₃	2	8.304	8.304	8.304	8.304*	7.888
	B ₄	9	7.367	7.542	7.474	7.492	6.846
	B ₅	7	7.769	7.818	7.767	7.818*	7.533
	B ₆	12	7.614	7.621	7.616	7.622*	7.466
	B ₇	3	6.764	6.811	6.764	6.811*	6.306
	B ₈	7	7.441	7.417	7.441	7.455*	7.167
	Over-All Ave. Marg. Utility		7.623	7.650	7.643	7.672*	7.267

*denotes maximum in row

Then each method was used to assign another sample of 50 men to 16 ships. This sample, designated Group II, was composed of Boatswain's Mates, Quartermasters, and Signalmen of all pay grades. Group II was further subdivided into smaller sets to investigate the effect of sample size on each method of assignment. Using these subdivisions, each method was used to assign the 50 men of Group II to the 16 ships; but all the men in one subgroup were assigned before proceeding to the next subgroup. The size, number, and the results of these subdivisions are shown in Table 7. The assignments produced by each method of assignment for each sample of men were compared on the basis of average marginal utility of assignment as shown in Table 7.

The assignment utility used in the five processes of assignment is dependent on the preceding assignments; i.e., given a set of 50 assignments to make, the utility of the 16th assignment depends on the preceding 15 assignments. However, the marginal utility of any assignment (as defined in this paper) depends on all 49 other assignments. This marginal utility can be computed by considering each man individually after all assignments have been made. The procedure would be to take the first assignment and subtract the man from the assigned ship's POB-6 figure. Then recompute the affected W_{ijk} variables and use these new values to determine the utility of that assignment by the procedure described earlier in the paper. Before going on to the next assignment, the POB-6 is restored to its initial value.

It is obvious that a comparison based on marginal utility of assignment is preferred because it eliminates the effects of the order in which the assignments are made. As an example, assume that three Boatswain's Mates are assigned to the same ship by different methods of assignment and that they are assigned in different order. This means that the utility of assignment of each man is different for each method. However, the marginal utility of each man, as defined above, will be identical for each of the methods. Therefore, this gives an equal basis on which to compare the five different methods of assignment.

Since Group I was composed of only one rating, a more complete set of data was obtained and is presented in Tables 8 and 9. Table 8 allows a comparison, by pay-grade, of the distribution of assignment of 50 Boatswain's Mates to 16 ships. Table 9 can be used for analysis of the same set of assignments.

Analysis of the information presented in Tables 7, 8, and 9 leads to several conclusions about the different methods of assignment. Referring to Table 7, it can be noted that the VAM method made assignments which gave the maximum average marginal utility in 10 of the 12 sets of assignments which were made. This obviously accounts for the fact that the VAM method also had the highest over-all average marginal utility in both subgroups.

It can also be seen in Table 7 that the Decision Index method had the lowest average marginal utility in every case.

TABLE 8

Distribution Comparison of Five Methods of Assignment of 50 BM's

Rate	Ship No.	EDP (before assign)	POB (before assign)	No. Assigned by:					Ship No.	EDP (before assign)	POB (before assign)	No. Assigned by:				
				ROW	ARRAY	ROW-COL	VAM	D. I.				ROW	ARRAY	ROW-COL	VAM	D. I.
BMC	1	1	3	0	0	0	0	0	9	1	1	0	0	0	0	0
BM1		5	1	3	3	1	3	3		7	8	0	0	0	0	0
BM2		8	10	0	0	0	0	1		18	15	1	1	1	1	0
BM3		13	11	0	0	1	0	0		31	21	0	0	0	0	0
BMSN		1	2	0	0	0	0	0		0	2	0	0	0	0	0
BMC	2	1	0	1	2	1	1	1	10	1	1	0	0	1	0	0
BM1		5	4	1	0	1	1	2		4	3	1	1	1	1	0
BM2		8	9	0	0	1	0	1		8	9	0	0	0	0	0
BM3		13	14	0	0	0	0	0		16	10	1	1	1	1	1
BMSN		1	0	1	1	1	1	1		0	1	0	0	0	0	0
BMC	3	1	2	0	0	0	0	0	11	1	0	1	1	1	1	1
BM1		5	8	0	0	0	0	0		4	6	0	0	0	0	0
BM2		8	7	0	0	0	0	0		8	4	4	3	3	3	1
BM3		13	12	0	0	0	0	0		16	9	3	3	3	3	1
BMSN		1	0	1	1	1	1	1		0	1	0	0	0	0	0
BMC	4	1	3	0	0	0	0	0	12	1	1	0	0	0	0	1
BM1		5	2	2	3	3	2	2		4	4	0	0	0	0	0
BM2		8	6	2	2	2	2	0		8	11	0	0	0	0	0
BM3		13	8	2	2	2	2	0		16	12	0	0	0	0	4
BMSN		1	0	2	1	2	1	1		0	0	0	1	0	1	1
BMC	5	2	2	0	0	0	1	0	13	1	1	1	1	1	1	1
BM1		6	6	0	0	0	0	0		4	3	1	1	1	1	0
BM2		15	13	2	3	2	3	1		8	9	0	0	0	0	4
BM3		19	14	1	1	1	1	0		16	10	4	4	3	4	2
BMSN		0	2	0	0	0	0	0		0	1	0	0	0	0	0
BMC	6	2	1	1	1	1	1	1	14	1	2	0	0	0	0	0
BM1		6	6	0	0	0	0	0		2	2	0	0	0	0	0
BM2		19	18	0	0	0	0	0		4	3	1	1	1	1	0
BM3		31	18	2	2	2	2	1		6	7	0	0	0	0	0
BMSN		1	9	0	0	0	0	0		0	0	0	0	0	0	0
BMC	7	2	1	1	1	1	1	1	15	1	1	0	0	0	0	0
BM1		6	5	0	0	1	0	0		2	1	1	1	1	1	1
BM2		18	15	1	1	1	1	0		4	3	1	1	1	1	0
BM3		32	25	0	0	0	0	0		6	6	0	0	0	0	0
BMSN		1	1	0	0	0	0	0		0	2	0	0	0	0	0
BMC	8	2	1	1	1	1	1	1	16	1	1	1	0	0	0	0
BM1		6	8	0	0	0	0	0		2	1	1	1	1	1	2
BM2		18	22	0	0	0	0	4		4	2	2	2	2	2	2
BM3		32	24	2	2	2	2	6		6	8	0	0	0	0	0
BMSN		1	3	0	0	0	0	0		0	1	0	0	0	0	0

The utility of the remaining three methods varied with the size of the sample to be assigned. Unfortunately, the variance was not consistent and could not be defined by any of the usual mathematical techniques. Therefore, based on the data in Table 7, the highest average marginal utility was obtained when using the VAM method and the lowest when using the Decision Index method, regardless of the size of the sample. Although not presented in this paper, the authors investigated several other sample assignments. The results of this work tended to substantiate this relationship between the VAM and Decision Index methods.

Table 8 represents a detailed break-down of the assignment of Group I by each method. It can be seen that the Row, Array, Row-Column, and VAM methods effected a similar pattern of assignment distribution. For seven of the 16 ships the assignments were identical and for six other ships these four methods disagreed by only one assignment on each ship. Clearly, on the basis of this data, it is impossible to choose any one method as better than the other three. On the other hand, the pattern of distribution produced by the Decision Index method was definitely inferior to the other four methods. Some specific evidence of this poor distribution can be seen by inspection of the assignments made to Ships 4, 8, and 12. The Decision Index method did not assign nearly enough men to Ship 4 while it overfilled Ships 8 and 12. Of particular note, Ship 8 was

TABLE 9
Qualitative Parameters for Comparison of
Five Methods of Assignment of 50 BM's

Quality Parameters of Assignment Methods	Method				
	Row	Array	R-C	VAM	D. I.
(1) Total No. Men Assigned	50	50	50	50	50
(2) No. Men With Take-Up > 3 Mos. Before Deployment	12	13	12	18	11
(3) No. Men With Take-Up ≤ 3 Mos. Before Deployment	9	10	9	7	19
(4) No. Men With Take-Up During Deployment	12	11	11	9	12
(5) No. Men With EAOS After Deployment Return	50	50	46	50	49
(6) No. Men Receiving 1st HP Choice	6	7	5	7	7
(7) No. Men Receiving 2nd HP Choice	4	2	1	2	4
(8) No. Men Who Could Be Assigned to HP Preference	11	11	11	11	11
(9) Marginal Assignment Utility (Average)	7.602	7.608	7.465	7.727	7.103
(10) Assignment Utility (Average)	7.938	7.973	7.763	7.978	7.485
(11) Computer Run Time (Seconds)	135	135	158	132	143

overmanned by four BM2's and the Decision Index method assigned four more of that same pay grade. Obviously, this is an undesirable assignment pattern.

The assignment methods described in this paper each use a different procedure to assign any given group of men. Because of this fact, it is reasonable to expect that the order in which these men are assigned will differ with each assignment method. In order to investigate the effects of this ordering, Group I was assigned by each method. The results of these assignments as pertains to specific parameters is presented in Table 9.

Looking at rows (2) and (3) in Table 9, it can be seen that the Decision Index method assigned the men in such a manner that 30 of the 50 men were sent to ships preparing to deploy. Of these 30 men, 19 were sent to ships three months or less before deployment. Recalling that the authors' policy was to fill all ships preparing to deploy, the Decision Index method was the most desirable in this instance. However, looking down the list to row (4), the VAM method is favored over the other four methods in the fact that it assigned the least number of men (9) to ships which were already on deployment. Again, this is a desirable feature according to the authors' policy. At this point it might be noted that rows (2), (3), and (4) under each method do not sum to the total number of men assigned. This is due to the fact that ships which have just returned from a deployment do not have a firm date for their next deployment.

Until this date is known and can be entered into the program, men assigned to this ship do not fit into any of the categories of rows (2), (3), and (4).

The results in row (5) indicate that the Row-Column method assigned the men such that four of them were assigned to ships on which they could not complete the deployment. Clearly, this is an undesirable feature. Rows (6) and (7) show the number of men who received either their first or second homeport preferences for the ships which were considered. Based on homeport preferences, the Decision Index method is favored because it assigned all 11 men to a homeport of their choice.

Based strictly on the assignment parameters of rows (2) through (7), the Decision Index method would probably be most favored. However, when taking into account the weighting factors and the distribution of assignment mentioned earlier, row (9) shows the Decision Index method to give the lowest average marginal utility of assignment. The average assignment utility was included for the purposes of comparison [row (10)] and also shows the Decision Index method to have the lowest utility. Both rows (9) and (10) indicate that the VAM method is preferred on the basis of highest utility.

Another important consideration in comparing these five methods is the computer run time. It can be shown that the number of computer operations required in AUTAM is not a linear function of the number of ships and men, but rather

a polynomial involving multiplicative terms of higher order. Therefore, although a difference in run time of five seconds may be trivial for the assignment of 50 men to 16 ships, a very significant difference in run time could result when the number of ships and men is increased for application in the fleet. In row (11) of Table 9, the VAM method is shown to have the shortest computer run time. Computer run times shown in Table 9 include program compiling time, program listing, and computation of marginal utility. By eliminating the last two items and using a binary program deck, run time for VAM was reduced to 69 seconds.

All five assignment methods were capable of performing the assignment process. However, the Decision Index method was discounted as a useful procedure because of its poor assignment distribution. Each of the other four methods was considered more effective than the manual process of assignment. Since the VAM method achieved the maximum utility and required the minimum computer run time, it was chosen for implementation into the AUTAM model as shown in Appendix D. A sample printout of AUTAM, showing only those items useful to an assigner, is shown in Appendix F. For this printout a sample of ten ships and 30 men was used.

3. Summary and Conclusions.

Briefly, the development of AUTAM was as follows:

- (1) Selected man-related and ship-related parameters were compared in order to derive a set of assignment variables. These variables were used to describe the assignment function.
- (2) Weights were determined for these variables in accordance with a prescribed assignment "policy."
- (3) The weights and variables were incorporated into a computer program to compute the relative utility of each assignment of a given set of assignments.
- (4) Methods of assignment were investigated to determine a method which would make optimal assignments and require a minimum of computer run time.

AUTAM was then derived from the computer program of step (3) combined with a modified version of the Vogel Approximation Method as applied in step (4).

AUTAM demonstrates the feasibility of computerized personnel assignment. The authors do not claim that AUTAM is the only or best method of assignment, or that the techniques employed are unique. However, it is asserted that this program is capable of duplicating any "assignment policy" formulated by authoritative sources. In comparison with the present manual methods of assignment, AUTAM, or a program similar to it, has several major advantages:

- (1) Rapid. The most obvious advantage of a computerized system is that it is capable of assigning a given set of

men in only a fraction of the time required by manual methods. In addition, it could eliminate time-consuming accounting and order-writing procedures by proper integration into a centralized personnel accounting, distribution, and assignment system.

(2) Objective. A properly programmed computerized assignment process is much more objective than a qualified assigner because the computer is not subject to outside influences and personal feelings. Although it's listed here as an advantage, this cold objectivity of computerized assignment is attacked by many people on the grounds that the benefits of the "human touch" are being denied in the assignment process. In reality, all the desirable aspects of the "human touch" are included in a good assignment model. It is only the undesirable features, such as human boredom and fatigue, which are eliminated in computerized assignment. This elimination of undesirable human factors leads to the next advantage.

(3) Consistent. After determining the variables and corresponding weights which effectively describe the assignment policy, all assignments made by the computer would be in strict accordance with that policy. This process requires that the same qualitative factors be considered for each man for all possible assignments. In addition, after a specific weight has been determined for each factor, this weight must be maintained constant for all possible assignments. Certainly this is a consistency which is almost

impossible for a man to accomplish. A man can only attempt to perform the assignment task through the tedious process of repetitive subjective judgments. This very often leads to gross misuse of available manpower.

The above arguments in favor of computerized assignment are not meant to infer that skilled personnel assigners would no longer be needed. Although the number of assigners could be reduced, there would still be a requirement for handling special assignment problems. For example, it must be recognized that computers are not infallible. Therefore, each assignment should be checked by an experienced assigner. This would be a rapid spot-check for any glaring errors that would give evidence of computer malfunction. Also, the "additional information" contained on card(s) 5A of the assignment deck cannot easily be processed by the computer and may contain information which would affect the suitability of a given assignment. To more easily examine this information, it could be printed out with the computed assignment for further consideration by the assigner.

It is obvious that any assignment policy will change over a period of time. Minor changes could be reflected by an adjustment of the weight for the affected variable. However, major changes of assignment policy (usually a result of foreign conflict or other emergency) require a completely revised set of weights. In this case the entire

process of the determination of weights would have to be repeated. Hopefully, this situation will not occur often.

This thesis has attempted to show that computerized personnel assignment is both a feasible and a highly desirable process. On the basis of the results obtained in the use of AUTAM, it is highly recommended that the Navy consider implementation of a program of this sort. Proper application of this program will permit full consideration of the preferences of each man to be assigned. Simultaneously, the "needs of the Service" would be considered and assignments could then be made so that the utilization of manpower would be greatly increased while taking into account the preferences of the individual.

BIBLIOGRAPHY

- ✓ 1. Enlisted transfer manual. Department of the Navy, Bureau of Naval Personnel, Washington, D.C. NAVPERS 15909A. 22 March 1960.
2. Multiple regression with case combinations. Health Sciences Computing Facility, UCLA. Computer Program BMD03R, 13 August 1964.
- ✓ 3. Proposed five year program plan for personnel systems research department. U.S. Naval Personnel Research Activity, San Diego, California. 1 February 1965.
- ✓ 4. Tri-Service conference on new approaches to personnel-systems research. Office of Naval Research, Department of the Navy, Washington, D.C. ONR Symposium Report ACR-76. 23, 24 May 1962.
5. Baumol, W. J. Economics Theory and Operations Analysis. Prentice-Hall, Inc., New Jersey, 1961.
6. Bottenberg, R. A. and J. H. Ward Jr. Applied multiple linear regression. 6570th Personnel Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Lackland Air Force Base, Texas. Technical Documentary Report PRL-TDR-63-6. March, 1963.
7. Gulliksen, H. and L. R. Tucker. A general procedure for obtaining paired comparisons from multiple rank orders. Psychometrika, V. 26, No. 2. June, 1961.
8. Jackson, J. E. and M. Fleckenstein. An evaluation of some statistical techniques used in the analysis of paired comparison data. Biometrics, March, 1957.
- ✓ 9. King, W. R. Personnel evaluation and optimal assignment. Operations Research Group, Case Institute of Technology. ONR Project - NONR-1141(11). April, 1964.
- ✓ 10. Kossack, C. F. and R. E. Beckwith. The mathematics of personnel utilization models. Personnel Laboratory, Wright Air Development Center, Air Research and Development Command, United States Air Force, Lackland Air Force Base, Texas. Technical Report WADC-TR-59-359. November, 1959.

BIBLIOGRAPHY

11. Reinfeld, N. V. and W. R. Vogel. Mathematical Programming. Prentice-Hall, Inc., 1958.
12. Thorpe, R. P. and R. D. Conner. A computerized model of the fleet personnel distribution system. U.S. Naval Personnel Research Activity, San Diego, California. Research Report SRR 66-13. February, 1966.
13. Votaw, D. F., Jr. Functional tests of solutions of personnel assignment problems. Personnel Laboratory, Wright Air Development Center, Air Research and Development Command, United States Air Force, Lackland Air Force Base, Texas. Technical Report WADC-TR-59-358, ASTIA Document No. AD 229 881. August, 1959.
14. Walkup, D. W. and M. D. MacLaren. A multiple assignment problem. Mathematics Research Laboratory, Boeing Scientific Research Laboratories. Mathematical Note No. 347, DL-82-0346. April, 1964.
15. Ward, J. H., Jr. The counseling assignment problem. Psychometrika, V. 23, No. 1. March, 1958.
16. Ward, J. H., Jr. Use of a decision index in assigning Air Force personnel. Personnel Laboratory, Wright Air Development Center, Air Research and Development Command, United States Air Force, Lackland Air Force Base, Texas. Technical Report WADC-TN-59-38, ASTIA Document No. AD 214 600. April, 1959.
17. Ward, J. H., Jr. and K. Davis. Teaching a digital computer to assist in making decisions. 6570th Personnel Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Lackland Air Force Base, Texas. Technical Documentary Report PRL-TDR-63-16. June, 1963.
18. Wolfe, J. H. Personnel applications of operations research. U. S. Naval Personnel Research Activity, San Diego, California. PRASD Report No. 200. December, 1962.

15

NAVJAG 105 (REV. 2-64)

- Card 1A

APPENDIX A

- (1) Service Number.
Print positions 1 thru 7.
- (2) Sex. "W" for Waves, blank for male.
Print position 8.
- (3) Enlisted designator numeric code.
Refer to NMIS (NAVPERS 15,642, Part I (ACTIVE)) for Code.
Print position 9.
- (4) Limited duty classification code.
Blank if in all respects qualified to perform unlimited duty. Refer to NMIS (NAVPERS 15,642, Part I (ACTIVE)) for Code.
Print position 10.
- (5) Branch and class of service code.
Refer to NMIS (NAVPERS 15,642, Part I (ACTIVE)) for Code.
Print position 11.
- (6) Primary Dependence status code.
Refer to NMIS (NAVPERS 15,642, Part I (ACTIVE)) for Code.
Print position 12.
- (7) Present Citizenship status.
Refer to NMIS (NAVPERS 15,642, Part I (ACTIVE)) for Code.
Print position 13.
- (8) Type of Security Clearance held.
Refer to NMIS (NAVPERS 15,642, Part I (ACTIVE)) for Code.
Print position 14.
- (9) Year of birth.
Print positions 15 thru 16.
- (10) Evaluation of the individual as determined by the commanding officer and entered as a five digit code as outlined in Chapter 24.
Print positions 17 thru 21.
- (11) Educational achievement.
Refer to Chapter 24 for codes.
Print positions 22 thru 23.
- (12) Active duty obligation. Includes reenlistment and all extensions.
Print positions 24 thru 25.
- (13) Active duty base date (year).
Print positions 26 thru 27.
- (14) Primary Navy Enlisted Classification, when applicable. Refer to NEC Manual (NAVPERS 15,105) (series).
Print positions 28 thru 31.
- (15) Secondary Navy Enlisted Classification, when applicable.
Refer to NEC Manual (NAVPERS 15,105) (series).
Print positions 32 thru 35.
- (16) Recommended Navy Enlisted Classification, when applicable. Refer to NEC Manual (NAVPERS 15,105) (series).
Print positions 36 thru 39.
- (17) Broad duty preferences for personnel rotating from shore to sea duty.
Refer to Chapter 25 for broad duty preference.
Print positions 40 thru 41.
- (18) Four duty choices and school if desired. Refer to Chapter 25 for Codes.
Print positions 42 thru 57.
- (19) "X" punch if DUINS, otherwise leave blank.
Print position 58.
- (20) Purpose Identification Code.
Refer to BUPERSINST 7312.5(series).
Print positions 59 thru 61.
- (21) Month and year of detachment from present command. Refer to Chapter 24 for codes.
Print positions 62 thru 63.
- (22) Activity processing code entered and used only by PAMI and other machine installations.
Print positions 64 thru 68.
- (23) Distributor that man is being made available. Refer to Chapter 24 for codes.
Print positions 69 thru 71.
- (24) Special Category Code. Refer to Chapter 24 for codes.
Print positions 72.
- (25) Rate Code. For use by PAMI and other machine installations.
Print positions 73 thru 77.
- (26) Date card originally submitted to BUPERS. Refer to Chapter 24 for Code.
Print positions 78 thru 79.
- (27) Card number 2.
Print position 80.

CARD 2A

① 4310084 ② 4266CP ③ 3260TH 0466TH 1261CK

Diagram illustrating the mapping of digits to characters in the sequence "005K83002":

- Digit 4 points to the first '0'.
- Digit 5 points to the '5'.
- Digit 6 points to the '8'.
- Digit 7 points to the '3'.
- Digit 8 points to the second '0'.

MAYPERB PTT (REV. 2-64)																																																																	
S*RVIC N.M.B.R.										SEX										CAREER HISTORY																																								DIST. AVAIL TO		RATE CODE		CARE PERS. NO.	
																				SA																																												3	

- (1) Service number.
Print positions 1 thru 7.
- (2) Sex. "n" for waves, leave
blank for male.
Print position 8.
- (3) The past ten years of duty
station history as transcribed
from individual's service
jacket. Coded in accordance
with instructions contained in
Chapter 24.
Print positions 9 thru 68.
- (4) Distributor to which individuals
has been made available. Refer
to Chapter 24 for Codes.
Print positions 69 thru 71.
- (5) Special Category Code.
Refer Chapter 24 for
special codes.
Print position 72.
- (6) Rate Code. For use by PAMI
and other machine installations.
Print positions 73 thru 77.
- (7) Leave blank.
Print positions 78 thru 79.
- (8) Card number 3.
Print position 80.

53

APPENDIX A

[illegible]

- (1) Service number.
Print positions 1 thru 7.
- (2) Sex. "N" for waves, leave
blank for male.
Print position 8.
- (3) Schools attended. List in
inverse order of attendance.
Refer to Chapter 25 for Codes.
Print position 9 thru 68.
- (4) Distributor to which an individual
has been made available. Refer to
Chapter 24 for Codes.
Print positions 69 thru 71.
- (5) Special Category Code,
if applicable. Refer to
Chapter 24 for special
category codes.
Print position 72.
- (6) Rate Code. For use by PAMI and
other machine installations.
Print position 73 thru 77.
- (7) Leave blank.
Print position 78 thru 79.
- (8) Card number "4".
Print position 80.

CARD 4A

CARD 5A

- (1) Service number.
Print position 1 thru 7.
- (2) Sex. "W" for Waves, leave blank for males.
Print position 8.
- (3) Additional information
Additional comments.
Print positions 9 thru 68.
- (4) Distributor to which an individual has been made available. (Refer to Chapter 24 for distributional Codes)
Print positions 69 thru 71.
- (5) Special Category Code. (Refer to Chapter 24 for Codes).
Print Position 72.
- (6) Rate Code. For use by PAMI and other machine installations.
Print position 73 thru 77.
- (7) Consecutive card number.
Print positions 78 thru 79.
- (8) Card number "5"
Print position 80.

APPENDIX B

CODES USED IN ASSIGNMENT DECK

Month Codes

<u>Month</u>	<u>Code</u>
January	1
February	2
March	3
April	4
May	5
June	6
July	7
August	8
September	9
October	0 (zero)
November	J
December	B

Rate Codes

<u>Rate</u>	<u>Code</u>
BMC	01001
BM1	01002
BM2	01003
BM3	01004
BMSN	01005

APPENDIX B

Rate Codes

<u>Rate</u>	<u>Code</u>
QMC	02001
QM1	02002
QM2	02003
QM3	02004
QMSN	02005
SMC	02501
SM1	02502
SM2	02503
SM3	02504
SMSN	02505

APPENDIX B

Home Port Codes

A..... ANY PORT, ATLANTIC FLEET.
 B..... NEW CONSTRUCTION, ATLANTIC FLEET.
 C..... BOSTON, MASS. INCLUDES PORTSMOUTH, N. H.
 D..... NEW LONDON, CONN.
 E..... NEWPORT, R. I., INCLUDES QUONSET POINT, R. I., DAVISVILLE, R. I.,
 PROVIDENCE, R. I., FALL RIVER, MASS.
 F..... NEW YORK, N. Y., INCLUDES JAMAICA, N. Y., FORTSCHUYLER, N. Y.,
 PERTH AMBOY, N. J. PORT NEWARK, N. J.
 G..... PHILADELPHIA, PA., INCLUDES ATLANTIC CITY, N. J., TRENTION, N. J.,
 LAKEHURST, N. J.
 H..... WASHINGTON, D. C., INCLUDES PATUXENT RIVER, MD., BALTIMORE, MD.,
 I..... NORFOLK, VA., INCLUDES NEWPORT NEWS, VA., DAM NECK, VA., LITTLE
 CREEK, VA., OCEANA, VA., FORT STOREY, VA.
 J..... YORKTOWN, VA., INCLUDES CHINCOTEAGUE, VA.
 K..... CHARLESTON, S. C. INCLUDES BEAUFORT, S. C., WILMINGTON, N. C.,
 CHERRY POINT, N. C.
 L..... JACKSONVILLE, FLA., INCLUDES MAYPORT, FLA., GREEN COVE SPRINGS,
 FLA., SANFORD, FLA., GLYNCO, GA.
 M..... BRUNSWICK, ME., INCLUDES PORTLAND, ME.
 N..... NEW ORLEANS, LA., INCLUDES PENSACOLA, FLA., ST. PETERSBURG, FLA.,
 PANAMA CITY, FLA., MOBILE, ALA., HOUSTON, TEX., GALVESTON,
 TEX., PASCAGOULA, MISS.
 P..... MIAMI, FLA., INCLUDES PORT EVERGLADES, FLA., KEY WEST, FLA.
 Q..... CHICAGO, ILL., INCLUDES GREAT LAKES, ILL., MILWAUKEE, WISC.,
 SHEBOYGAN, WISC., DETROIT, MICH., BENTON HARBOR, MICH.,
 TOLEDO, OHIO, CLEVELAND, OHIO, ROCHESTER, N. Y.
 R..... OVERSEAS ATLANTIC, INCLUDES ANY HOMEPORT OVERSEAS IN THE
 ATLANTIC OCEAN OR MEDITERRANEAN SEA.
 O..... NO PREFERENCE, EITHER FLEET, ANY PORT.
 S..... OVERSEAS PACIFIC, INCLUDES ANY HOMEPORT OVERSEAS IN THE PACIFIC
 OCEAN OR INDIAN OCEAN.
 T..... ANY PORT, PACIFIC FLEET.
 U..... NEW CONSTRUCTION, PACIFIC FLEET.
 V..... SEATTLE, WASH., INCLUDES PUGET SOUND, WASH., EVERETT, WASH.,
 BREMERTON, WASH., WHIDBEY ISLAND, WASH., ASTORIA, ORE.,
 PORTLAND, ORE., TONGUE POINT, ORE.
 W..... SAN FRANCISCO, CALIF., INCLUDES MARE ISLAND, CALIF., VALLEJO,
 CALIF., ALAMEDA, CALIF., CONCORD, CALIF., MOFFETT FIELD,
 CALIF., STOCKTON, CALIF.
 X..... LONG BEACH, CALIF., INCLUDES SAN PEDRO, CALIF., POINT MUGU,
 CALIF., PORT HUENEME, CALIF., LOS ALAMITOS, CALIF.
 Y..... SAN DIEGO, CALIF., INCLUDES NORTH ISLAND, CALIF., MIRAMAR, CALIF.,
 REAM FIELD, CALIF., BROWN FIELD, CALIF.
 Z..... PEARL HARBOR, HAWAII, INCLUDES BARBERS POINT, HAWAII.

APPENDIX C

DATA DECK ORDER AND FORMAT DESCRIPTION

<u>Card No.</u>	<u>Description</u>	<u>Column No. (Inclusive)</u>	<u>Field Speci- fication</u>
1	Control Card		
	No. sets of data (NSET)	9,10	I10
	No. of ships (NSHIP)	19,20	I10
2	Ship Information (KS)		
	Hull no., name	1-16	A8
	Deploy month (code)	21	A8
	Deploy year "	22	I1
	Return month "	31	A1
	Return year "	32	I1
	Homeport "	41	A1
	Ship identity no.	44-45	I2
	(one card for each ship)		
3	EDP-POB Information		
(a)	EDP- BMC	1-4	F4.0
	BM1	5-8	"
	BM2	9-12	"
	BM3	13-16	"
	BMSN	17-20	"
	QMC	21-24	"
	QML	25-28	"

APPENDIX C

<u>Card No.</u>	<u>Description</u>	<u>Column No. (Inclusive)</u>	<u>Field Speci- fication</u>
3	EDP- QM2	29-32	F4.0
	QM3	33-36	"
	QMSN	37-40	"
	SMC	41-44	"
	SM1	45-48	"
	SM2	49-52	"
	SM3	53-56	"
	SMSN	57-60	"
	Ship identity no.	69-76	A8
	(one card for each ship)		
(b)	POB - exactly same format as above		
	(one card for each ship)		
4	Weights - a ₀	1-5	F5.2
	a ₁	6-10	"
	a ₂	11-15	"
	a ₃	16-20	"
	a ₄	21-25	"
	a ₅	26-30	"
	a ₆	31-35	"
	a ₇	36-40	"
	a ₈	41-45	"
	a ₉	46-50	"
	a ₁₀	51-55	"
	a ₁₁	56-60	"

APPENDIX C

<u>Card No.</u>	<u>Description</u>	<u>Column No. (Inclusive)</u>	<u>Field Speci- fication</u>
5	No. of men in set	9,10	I10
6	Assignment cards 1A and 2A for each man. Format in accordance with Appendix A.		

Repeat 5 and 6 for each set of men to
be assigned.

DATA CARD NO. 1

[illegible]

10

DATA CARD(S) NO. 2

[illegible]

USS	GOLF	05	66	Y	7
USS	XILO	85	56	X	1
USS	ESCH	95	47	W	5
USS	OSCAR	85	67	Y	2
USS	LIMA	95	67	X	1
USS	JULIET	16	76	X	8
USS	HOTEL	56	37	Y	9
USS	FOXTROT	45	65	W	4
USS	DELTA	85	86	W	2
USS	BRAVO	35	86		

APPENDIX C

DATA_CARD(S) NO. 3(A)

[illegible]

DATA-CARD(S) NO. 3(B)

[illegible]

-----COLUMN INDEX FOR DATA CARDS-----

[illegible]

30

10. .26 -.3 1.41 .33 -3.5 -1.59-2.27-1.94-.88 -3.14-1.82

DATA CARD(S) NO. 5

[illegible]

APPENDIX C

DATA CARD(S) NO. 6.

7184408	MOORE KENN	BMI	MCBASE	CP	LEJUN	C33026	7	0502B295536403	01002151
7718408	150 291111111	B8480000000	PIAS	CBJYP	FRA			C3302403	010020301
44518802	MAY CHARLES D	SM2	NAVSTA	SDIEG	OTH			115JP3005J5403	F02503001
4434746803	34033600000	1207650000000	NAVSTA	SDIEG	OTH			2NB6C7264403	F02503002
33746803	TAYLOR W C	SM2	NAVSTA	LBEACH	AS	AR		117JB2985J5403	F02503002
99954205	12 3900000	09570000000	NAVSTA	LBEACH	AS	C724828J6	1	2NB6C7264403	F02503002
99954205	NAKAMOTO W	BMI	COMMSTA	SFRISCO	C76046	DLGMSOJAACSSA	7	1202B295536403	01002151
54008135	120 29323411168	480000000	NAVSTA	SFRAN	Y	ZWDD CAGCLGQTH		1250P300505403	010020401
5208925	THOMPSON K H	BMI	NAVSTA	SFRAN	Y	YTBVTM		NDJ C7638403	0100401
5208925	ANDERSON W	BMI	USNH	CP	LEJUN	NCC31366	7	0502B295536403	01004151
522149225	110 40222322287	580000000	USNH	CP	LEJUN	NCC31366		C3136403	01004151
522149225	HADLEY MEL	BMI	USNH	SAN DIEGO	NWDE	CVAMSO		C3136403	01004151
6865925	130 41330533338	580000000	USNH	SAN DIEGO	NWDE	CVAMSO	7	1102B295536403	01004151
6865925	GIFFORD D J	QMS	TAP114	GEN WM MITCHEL	YWAR	AF AVSJJAA		C7154403	01004151
4198530	SPENCER W F	BMSN	NAVSTA	NORVA	C32626DJ6		1	058082985J5403	02004151
4198530	13 32000001280	590000000	NAVSTA	NORVA	C32626DJ6			2NDJ6C3142403	01005151
774969333	DUDLEY DONALD E	SM2	NS	LBEACH	OTH	CDAS		1170P299505403	01005151
774969333	130 35322321087	530000000	NS	LBEACH	OTH	CDAS		242957248403	01005151
48437355	VEGA CHARL	QMI	LSD	27	WHEATSTON	PT	6	4032B295546703	02002301
48437355	130 41234211157	590000000	NS	QUONSE	PT	311846		P4022703	02002301
655292422	BARAN EDWA	BMC	NAS	QUONSE	PT	311846	7	0108B295516403	01001151
655292422	100322111111167	4200005342	NAS	QUONSE	PT	311846		C1184403	01001151
56595541	VILLASENOR	BMI	OTS	PAS	ANN	LBCHC73766	7	1101B2995526403	01002151
56595541	3150 26222111177	400005342	OTS	PAS	ANN	LBCHC73766		C7376403	01002151
57172566	DOWNS H P	QMS	TAP114	GEN WM MITCHEL	YWAR	AF AVSJJAA		403JP2985B5403	02003151
57172566	015 17530000		TAP114	GEN WM MITCHEL	YWAR	AF AVSJJAA		403JP2985B5403	02003151
5735557	ENGLAND I L JR	BMI	NAVSTA	ADAK				4032P298546403	01004301
5735557	011		NAVSTA	ADAK				4032P298546403	01004301

COLUMN INDEX FOR DATA CARDS									
0	1	2	3	4	5	6	7	8	9
0000000001	1111111111	2222222222	3333333333	4444444444	5555555555	6666666666	7777777777	8888888888	9999999999
112345678901	2345678901	3456789012	4567890123	5678901234	6789012345	7890123456	8901234567	9012345678	0123456789

DATA CARD(S) NO. 6

[illegible]

APPENDIX D

DESCRIPTION OF PROGRAM AUTAM

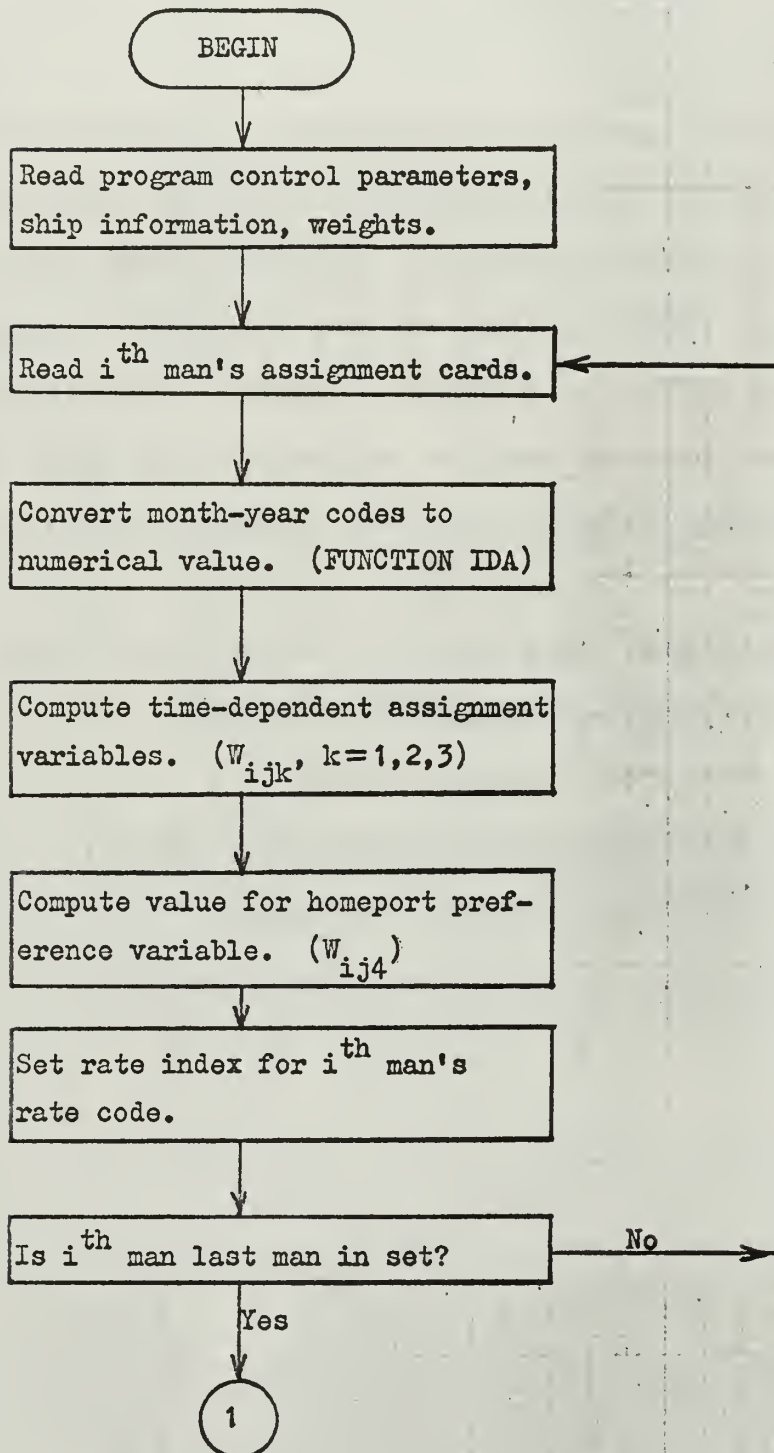
AUTAM was written in FORTRAN-63 for use on the CDC-1604 computer at the Naval Postgraduate School, Monterey. AUTAM consists of the main program, PROGRAM AUTAM; one function subprogram, FUNCTION IDA; and two subroutine subprograms, SUBROUTINE RATIO and SUBROUTINE ASSIGN. The interrelation of the main program and the subprograms is shown in the plain-language generalized flow chart in Part 1 of this appendix.

In Part 2 of this appendix, each part of the complete program is described in more detail by:

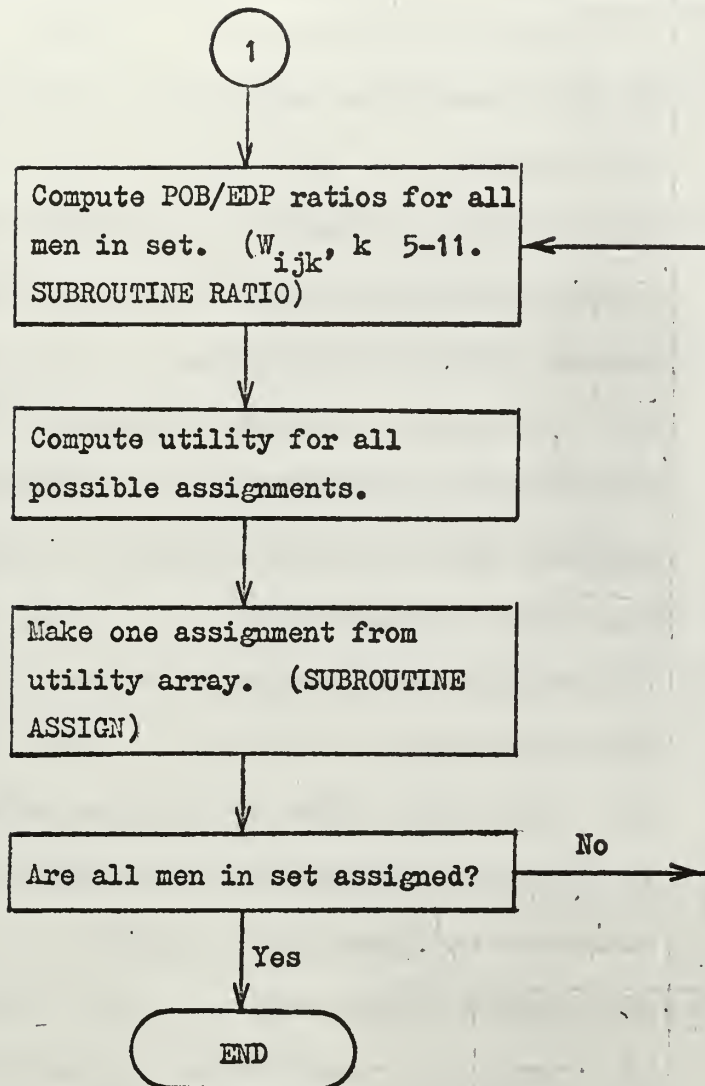
- (1) Table of Variables Used,
- (2) Detailed Plain-language Flow Chart,
- (3) FORTRAN-63 Program Listing.

APPENDIX D

Part 1. AUTAM Generalized Block Diagram



APPENDIX D



APPENDIX D

TABLE OF VARIABLES AND CONSTANTS IN PROGRAM AUTAM

- | | | |
|----|--------|---|
| 1. | A(K) | Weight vector for assignment variable.
(Constant) |
| 2. | GR(K) | Dummy variable used in conjunction with computation of marginal utility. Contains sum of W(I,J,K) elements. |
| 3. | I | Row subscript. Usually refers to I th man. |
| 4. | IDA | Function subprogram used to convert alphanumeric date code to number of months from base date (January 65). |
| 5. | ID(J) | Identifies to which ship the set of 15 EDP values belong. |
| 6. | IK(LM) | The sequential order of assignments. (Used in comparing assignment methods, in conjunction with marginal utility. |
| 7. | IM(I) | The number of the ship to which the I th man was assigned. Zero value indicates man has not yet been assigned in assignment process. Set to 99 if I th man has rate code error. |
| 8. | IP(J) | Relates POB values to proper ship. (ID(J) and IP(J) used to insure proper ordering of data deck.) |

APPENDIX D

- 9. IR(I) A rate code index for I^{th} man. Relates his rate code to proper column in (EDP)/(POB) array.
- 10. IRUN Iteration index for number of sets of men to be assigned.
- 11. I2 Iteration index for number of assignments made.
- 12. ISD Numerical conversion (by IDA) of ship's deployment date code.
- 13. ISR Numerical conversion (by IDA) of ship's return from deployment date code.
- 14. ITU Numerical conversion (by IDA) of man's take-up date code.
- 15. IXE Numerical conversion (by IDA) of man's EAOS date code.
- 16. J Column subscript - usually refers to J^{th} ship.
- 17. JA,JB Control indices for computation and recomputation of (POB)/(EDP) ratio and utility. After an assignment utility and (POB)/(EDP) ratio recomputed only for ship just assigned to.
- 18. K Element index for W_{ijk} vector describing assignment of I^{th} man to J^{th} ship.

APPENDIX D

19. KS(I,J) Hull no., name, deployment dates, homeport and identification number corresponding to ID(J), IP(J) for Jth ship.
20. MA(I,J) Data vector, for Ith man, taken from assignment deck. (Name, serial no., rate, rate code, etc.)
21. MR(I) Rate code table which is compared to man's rate code to find rate code index IR(I).
22. N Number of men in set to be assigned.
23. NSHIP Number of ships to be assigned to.
24. SA(I,J) Array of (POB)/(EDP) values for ships.
(NSHIP X 30)
First 15 cols: EDP Next 15 cols: POB
25. W(I,J,K) N X NSHIP array of vectors describing assignment of Ith man to Jth ship.

APPENDIX D

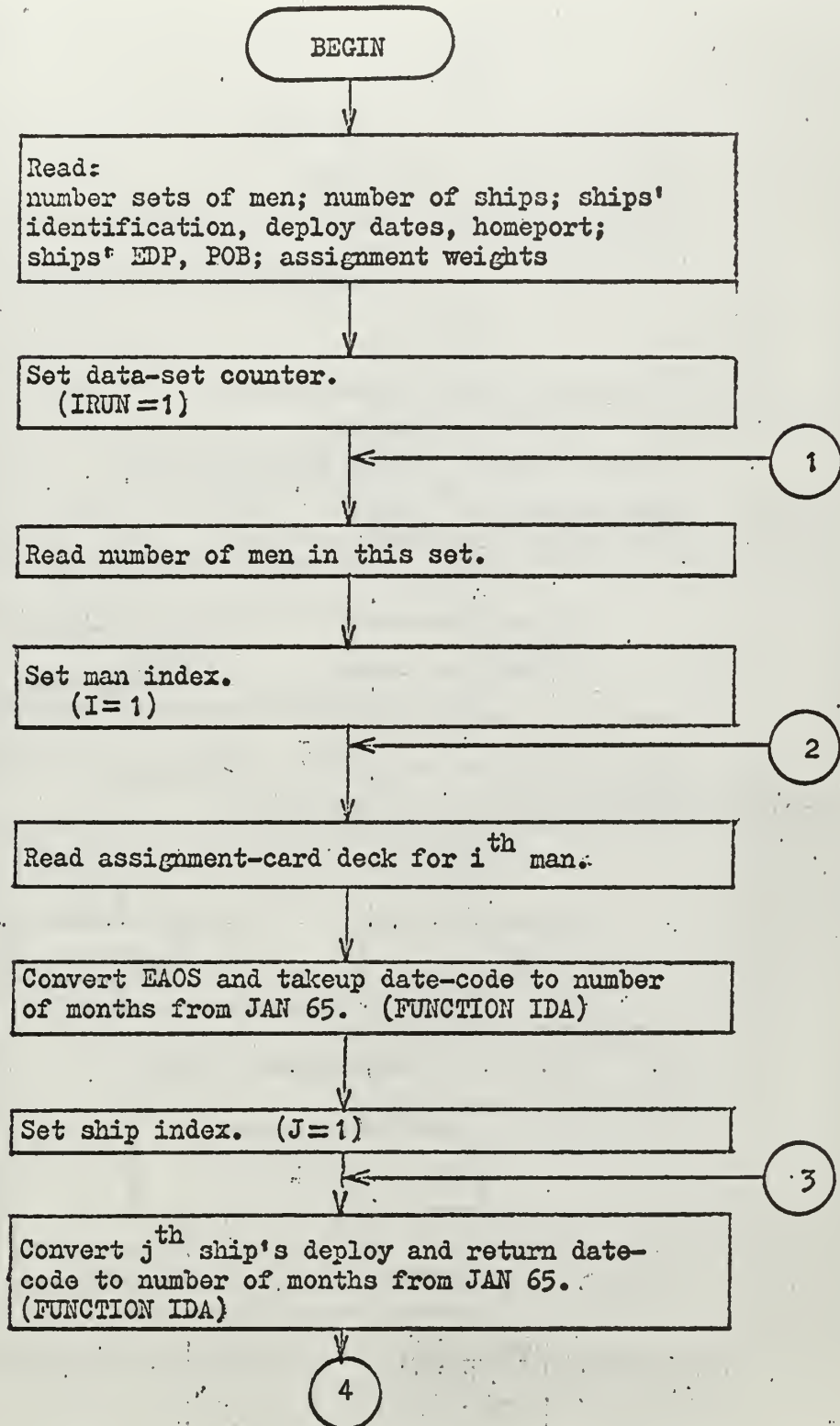
- 9. IR(I) A rate code index for I^{th} man. Relates his rate code to proper column in (EDP)/(POB) array.
- 10. IRUN Iteration index for number of sets of men to be assigned.
- 11. I2 Iteration index for number of assignments made.
- 12. ISD Numerical conversion (by IDA) of ship's deployment date code.
- 13. ISR Numerical conversion (by IDA) of ship's return from deployment date code.
- 14. ITU Numerical conversion (by IDA) of man's take-up date code.
- 15. IXE Numerical conversion (by IDA) of man's EAOS date code.
- 16. J Column subscript - usually refers to J^{th} ship.
- 17. JA,JB Control indices for computation and recomputation of (POB)/(EDP) ratio and utility. After an assignment utility and (POB)/(EDP) ratio recomputed only for ship just assigned to.
- 18. K Element index for W_{ijk} vector describing assignment of I^{th} man to J^{th} ship.

APPENDIX D

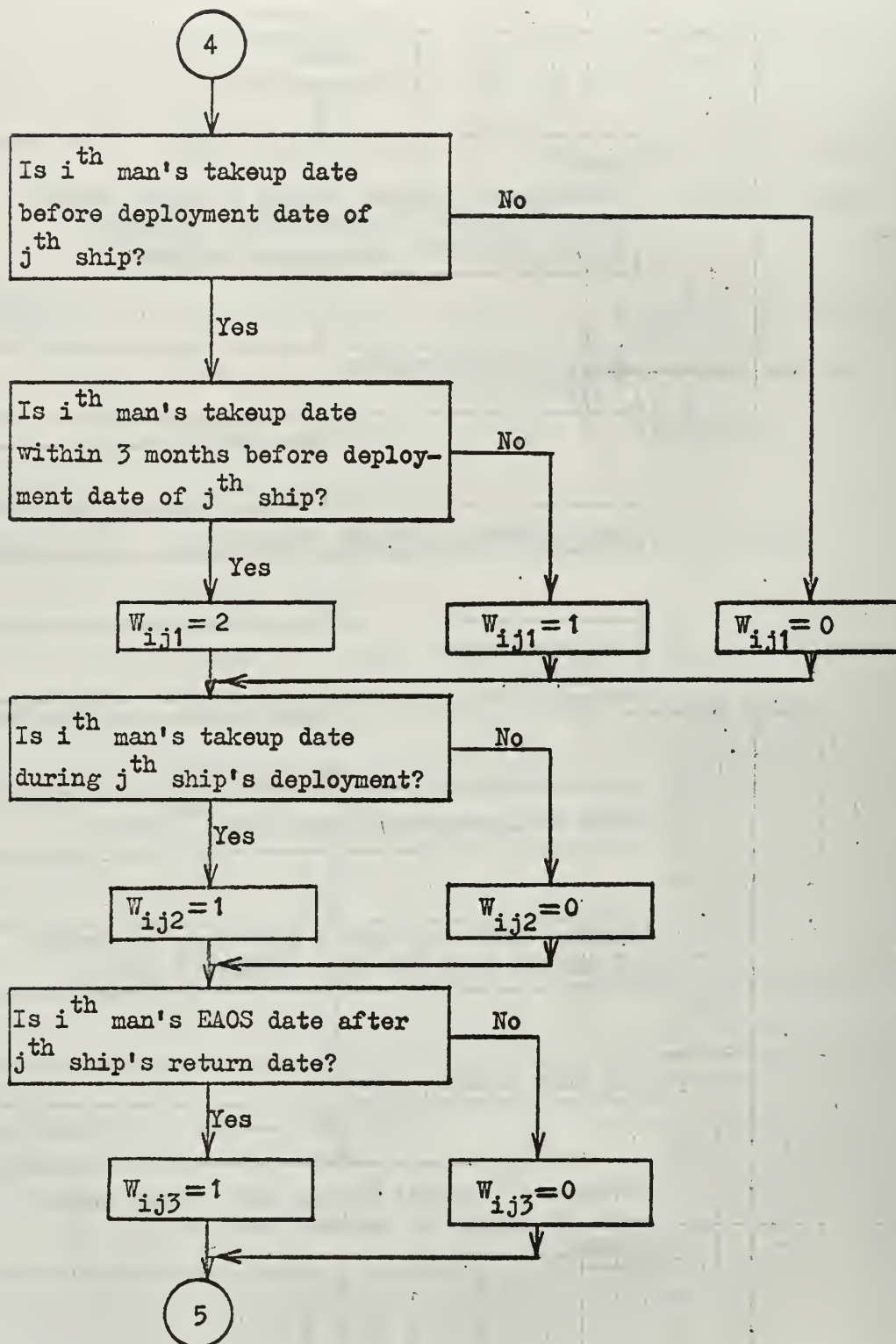
- 19. KS(I,J) Hull no., name, deployment dates, homeport
and identification number corresponding to
ID(J), IP(J) for Jth ship.
- 20. MA(I,J) Data vector, for Ith man, taken from assign-
ment deck. (Name, serial no., rate, rate
code, etc.)
- 21. MR(I) Rate code table which is compared to man's
rate code to find rate code index IR(I).
- 22. N Number of men in set to be assigned.
- 23. NSHIP Number of ships to be assigned to.
- 24. SA(I,J) Array of (POB)/(EDP) values for ships.
(NSHIP X 30)
First 15 cols: EDP Next 15 cols: POB
- 25. W(I,J,K) N X NSHIP array of vectors describing
assignment of Ith man to Jth ship.

APPENDIX D

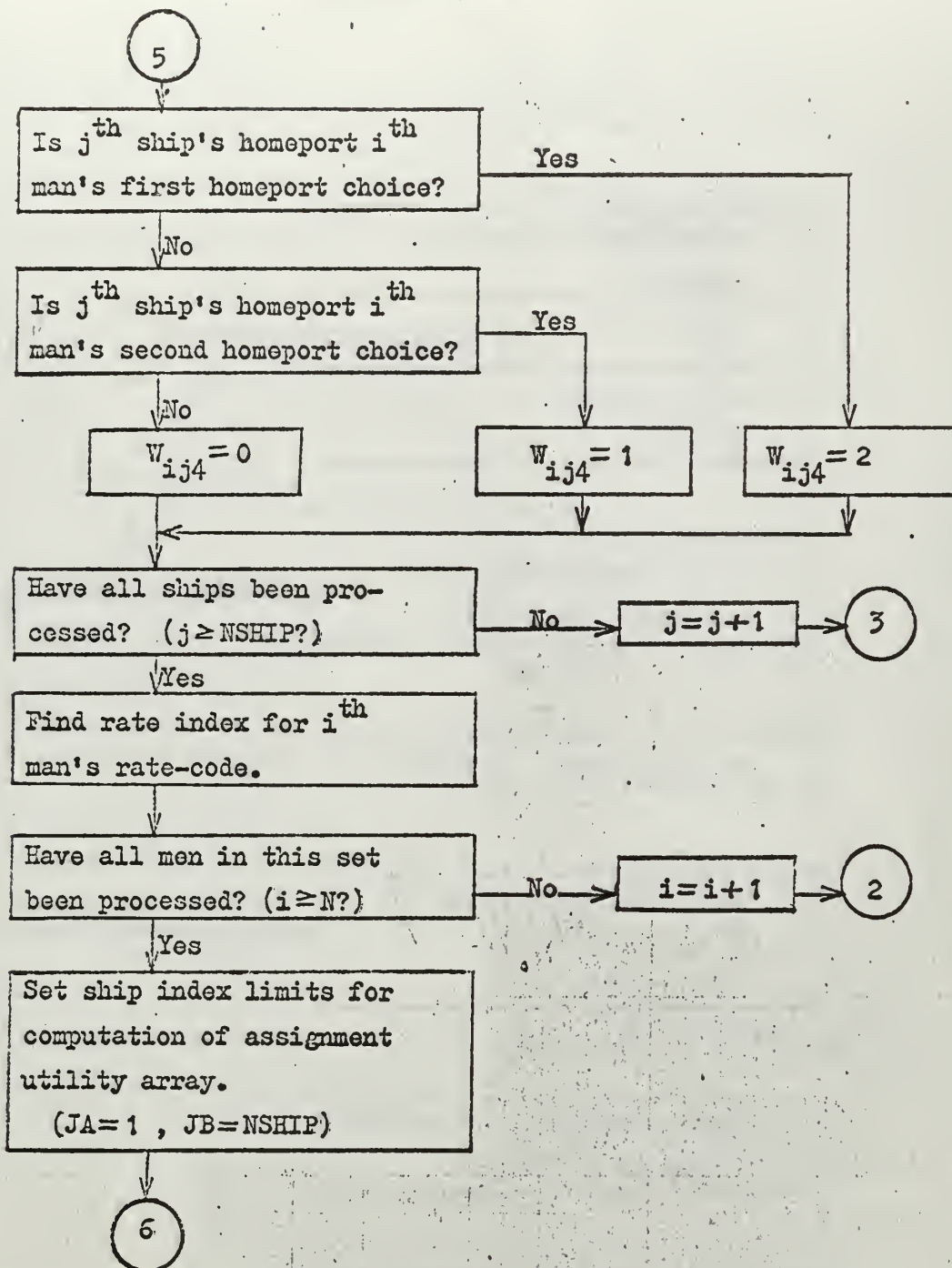
Detailed Plain-Language Flow-Chart for AUTAM



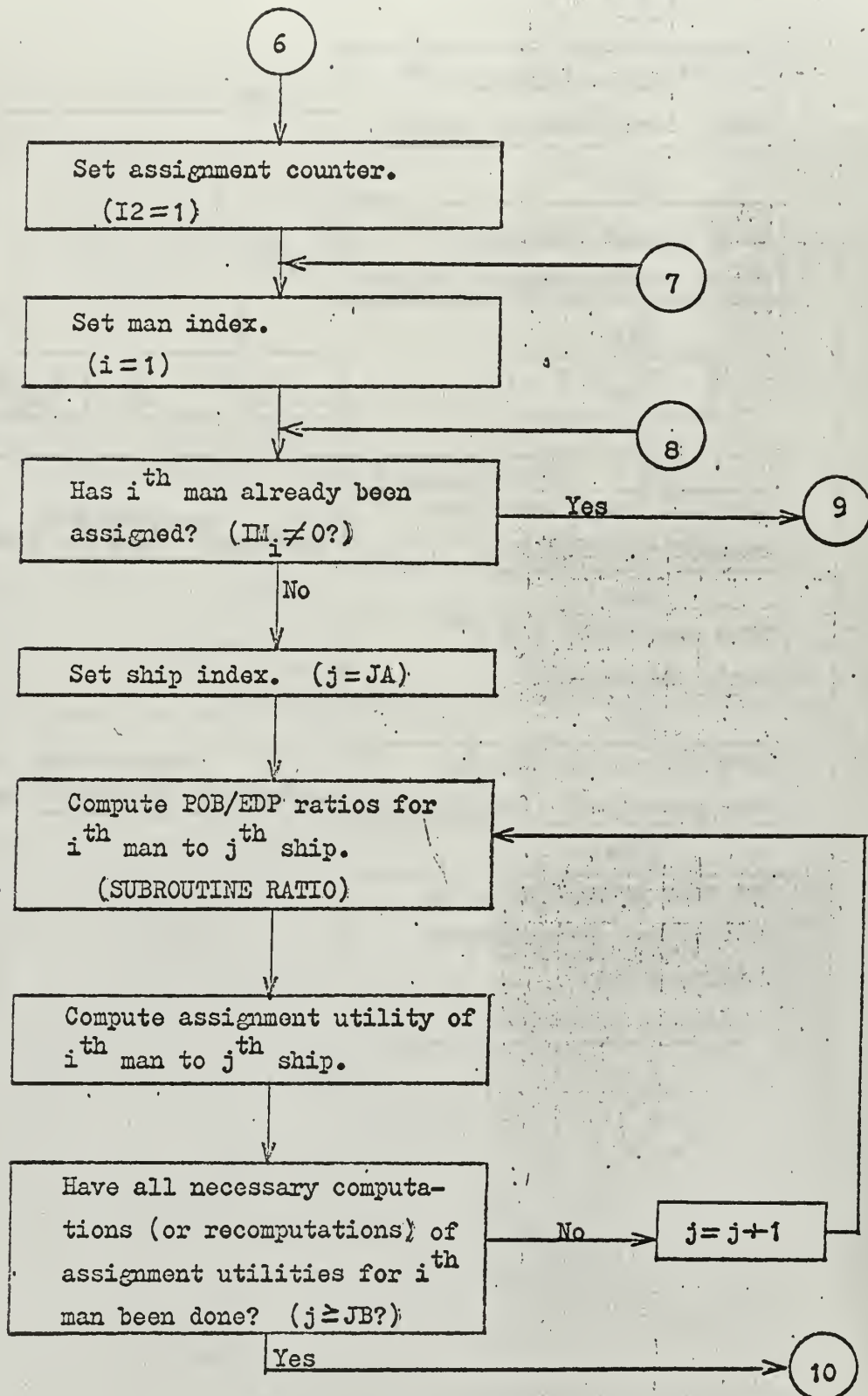
APPENDIX D



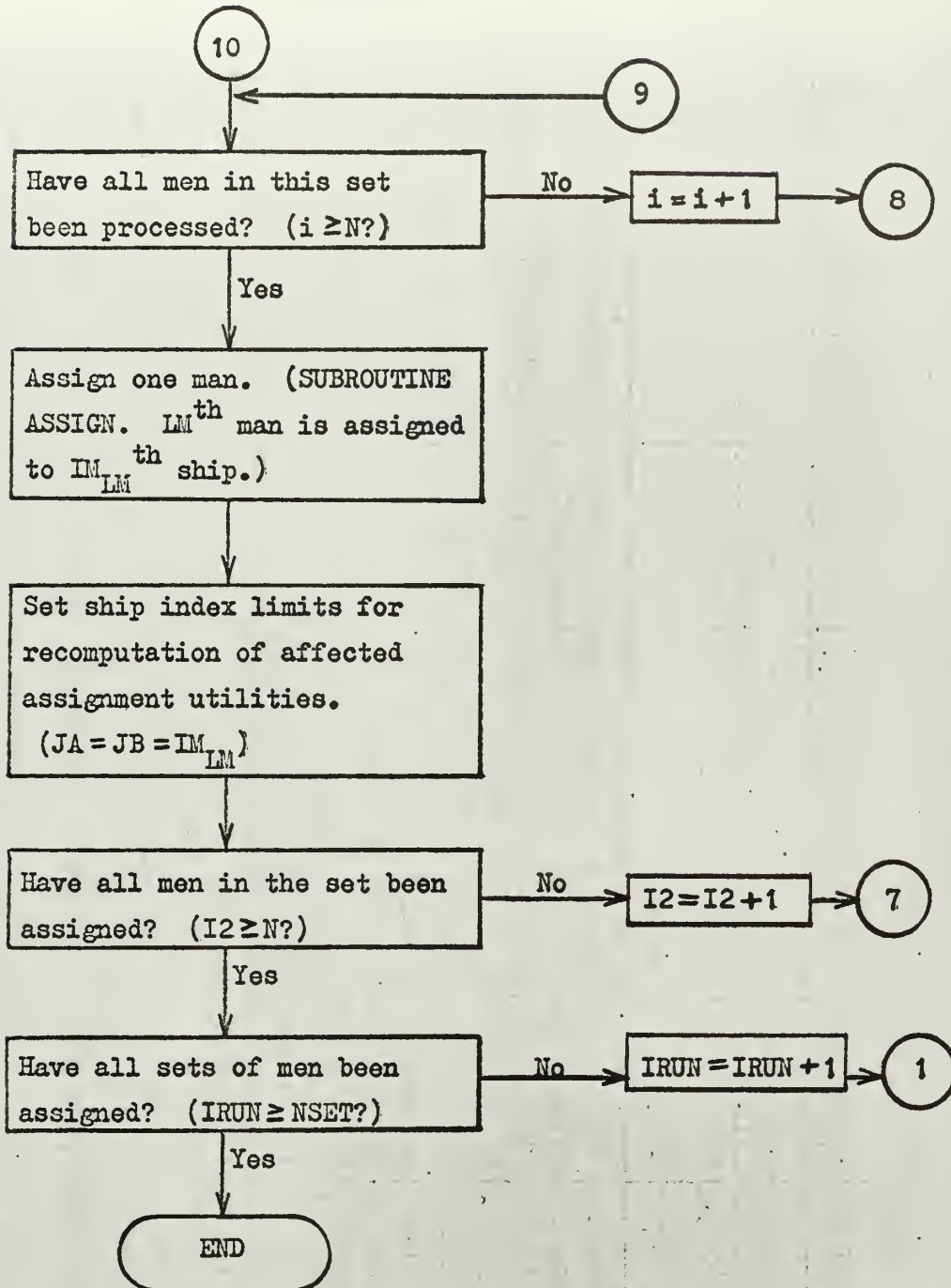
APPENDIX D



APPENDIX D



APPENDIX D



APPENDIX D

```

0000
0001
0002
0003
0004
0005
0006
0007
0008
0009
0010
0011
0012
0013
0014
0015
0016
0017
0018
0019
0020
0021
0022
0023
0024
0025
0026
0027
0028
0029
0030
0031
0032
0033
0034
0035

PROGRAM AUTAM

    DIMENSION KS(8,16),SA(30,16),W(50,16,15),IM(50),A(12),IR(50),
    1MA(50,15),ID(16),MR(15),U(50,16),IK(50),GR(50),IP(16)
    COMMON SA,W,MA,KS,U,NSHIP
    DATA(MR=01001,01002,01003,01004,01005,02001,02002,
    102003,02004,02005,02501,02502,02503,02504,02505)

C
C NSET = NO. SETS OF DATA TO BE RUN
C NSHIP (NO. OF SHIPS) MAX IS 16 FOR THIS PROGRAM
C KS(I,J) INFORMATION ON JTH SHIP I= 1,HULL NO., 2,NAME, 3 -DEPLOY MO
C 4-DEPLOY YR, 5-RETURN MO, 6-RETURN YR, 7-HOME PORT
C SA(I,J),I=1,15 = EDP FOR JTH SHIP. I = 16,30 = POB-6 FOR JTH SHIP
C A(K) IS THE WEIGHT ASSIGNED TO THE DECISION FACTOR W(I,J,K) FOR THE
C ASSIGNMENT OF THE ITH MAN TO THE JTH SHIP. THE SUMMED PRODUCT
C A(K)*W(I,J,K),K = 1, 12, DEFINES THE UTILITY OF THE ASSIGNMENT OF THE
C ITH MAN TO THE JTH SHIP.
C N IS NO. MEN TO BE ASSIGNED (MAX N IS 50)
    READ 49,NSET,NSHIP
    READ 10,((KS(I,J),I=1,8),J=1,NSHIP)
    READ 11,((SA(I,J),I=1,15),ID(J)),J=1,NSHIP)
    READ 11,((SA(I,J),I=16,30),IP(J)),J=1,NSHIP)
    READ 881,(A(K),K=1,12)
    DO 999 IRUN=1,NSET
    READ 49,N
    70 DO 89 I=1,N

C
C IM INDICATES WHETHER MAN IS ALREADY ASSIGNED, OR HAS RATE CODE ERROR
C
    IM(I) = 0
    DO 89 J=1,NSHIP
    DO 89 K=1,15
    89 W(I,J,K)=0.
    DO 72 I=1,N

C
C READ 1A, 2A CARD FOR ITH MAN, PERFORM ALL COMPUTATIONS AND COMPARISON

```

APPENDIX D

```

C MA(I,J) = ALL PERSONAL INFO ON ITH MAN
C FOR J = 1-SN,SEX, 2,3-NAME, 4,5,6-RATE AND PRESENT LOCATION, 7-TC
C 8,9-TAKE-UP DATE, 10-RATE CODE, 11-NO.DEPN., 12,13-EAOS, 14,15-HP PRE
C
C      READ 2,(MA(I,J),J=1,15)
C      ITU=IDA(MA(I,8),MA(I,9))
C      IXE=IDA(MA(I,12),MA(I,13))
C      63 DO 35 J=1,NSHIP
C
C      CONVERT YR-MO CODES TO NO. MO. FROM JAN 65
C      DATES - ISD = DEPLOY, ISR = RETURN, ITU = TAKEUP, IXE = EAOS
C
C      73 ISD=IDA(KS(3,J),KS(4,J))
C      ISR=IDA(KS(5,J),KS(6,J))
C
C      W(I,J,1)-IS TAKEUP BEFORE DEPLOYMENT
C
C      IF(ISD-ITU)25,25,22
C      22 IF(ISD-ITU-3)21,21,24
C      21 W(I,J,1)=2. $ GO TO 25
C      24 W(I,J,1)=1.
C
C      W(I,J,2)-IS TAKEUP DURING DEPLOYMENT
C
C      25 IF(ISD.LT.ITU.AND.ITU.LT.ISR)26,28
C      26 W(I,J,2)=1.
C
C      W(I,J,3)-IS EAOS AFTER DEPLOYMENT RETURN
C
C      28 IF(IXE-ISR)301,30,30
C      30 W(I,J,3)=1.
C
C      W(I,J,4)-IS SHIP HP ONE OF MANS PREFERENCES
C
C      301 IF(MA(I,14).EQ. KS(7,J))31,32

```

APPENDIX D

```

31 W(I,J,4)=2.$ GO TO 35
32 IF(MA(I,15).EQ. KS(7,J))33,35
33 W(I,J,4)=1.
C
C MATCH MANS RATE CODE TO ROW INDEX IN SA(I,J) MATRIX
C
35 CONTINUE
DO 42 M =1,15
IF (MA(I,10) - MR(M))43,41,42
41 IR(I) = M
GO TO 44
42 CONTINUE
43 PRINT 45,MA(I,2),MA(I,4)
IM(I) = 99
GO TO 72
44 CONTINUE
72 CONTINUE
C
PRINT 53,IRUN
PRINT 400
PRINT 401,((I,(MA(I,J),J=1,6),MA(I,8),MA(I,9),(MA(I,J),J=12,15))),
1I=1,N)
PRINT 402,((I,A(I)),I=1,12)
PRINT 403
PRINT 404, (J,(KS(I,J) ,I=1,8),J=1,NSHIP)
PRINT 54
PRINT 52
PRINT 51,(((SA(I,J),I=1,15),ID(J),(SA(I,J),I=16,30),IP(J)),J=1,NSH
1IP)
JA = 1 $ JB = NSHIP
DO 90 I2=1,N
C
C EXECUTE THIS LOOP FOR ASSIGNMENT
C
DO 88 I=1,N

```

0071
0072
0073
0074
0075
0076
0077
0078
0079
0080
0081
0082
0083
0084
0085
0086
0087
0088
0089
0090
0091
0092
0093
0094
0095
0096
0097
0098
0099
0100
0101
0102
0103
0104
0105

```

0106 GR(I)=0.
0107 IF(IM(I))84,84,88
0108 84 DO 189 J=JA,JB
0109 CALL RATIO(IR(I),I,J)
0110 U(I,J)=A(1)
0111 DO 189 K=1,11
0112 U(I,J)=U(I,J)+W(I,J,K)*A(K+1)
0113 189 CONTINUE
0114 88 CONTINUE
0115 CALL ASSIGN(N,IR,IM,LM)
0116 IK(LM)=I2
0117 JA=IM(LM)
0118 JB=IM(LM)
0119 90 CONTINUE
0120
0121 PRINT 55
0122 PRINT 52
0123 PRINT 51,(((SA(I,J),I=1,15),ID(J),(SA(I,J),I=16,30),IP(J)),J=1,NSH
0124 1IP)
0125 999 CONTINUE
0126 2 FORMAT(6A8,13X,A5,A1,I1,4X,I5/11X,I1,11X,A1,I1,14X,2A1)
0127 10 FORMAT(2A8,4X,2(A1,I1,8X),A1,4X,I2)
0128 11 FORMAT (15F4.0,8X,A8)
0129 45 FORMAT (20H ERROR IN RATE CODE ,2A8)
0130 49 FORMAT(2I10)
0131 51 FORMAT(3(5F4.0, 5X),A8,/,3(5F4.0, 5X),A8,/,/)
0132 52 FORMAT (40X7HEDP/POB,/,/,10X2HBM23X2HQM23X2HSM,/,/)
0133 53 FORMAT(1H130X27H** BEGIN RUN FROM DATA SET I2,3H **,/,/)
0134 54 FORMAT(1H1,32X,19H(BEFORE ASSIGNMENT))
0135 55 FORMAT(1H1,32X,19H(AFTER ASSIGNMENT))
0136 400 FORMAT(1H0/30X18HMEN TO BE ASSIGNED,/,/)
0137 401 FORMAT(1H 12,3X,6A8,3X,3HTU ,A1,I1,3X5HEAOS ,A1,I1,3X3HHP ,2A1)
0138 402 FORMAT(1H0/20X27H WEIGHTS USED IN ASSIGNMENT/12(/27X3H A(
0139 112,2H)=F6.3))
0140 403 FORMAT(1H0/20X23HSHIPS TO BE ASSIGNED TO/ )

```

C

APPENDIX D

```
404 FORMAT(5X,I2,5X,2A8,4X,2(A1,I1,8X),A1,I8)  
881 FORMAT(12F5.2)  
END
```

0141
0142
0143

2

APPENDIX D

Part 2

Function Subprogram IDA

Subroutine Subprogram RATIO

Subprogram Subroutine ASSIGN

APPENDIX D

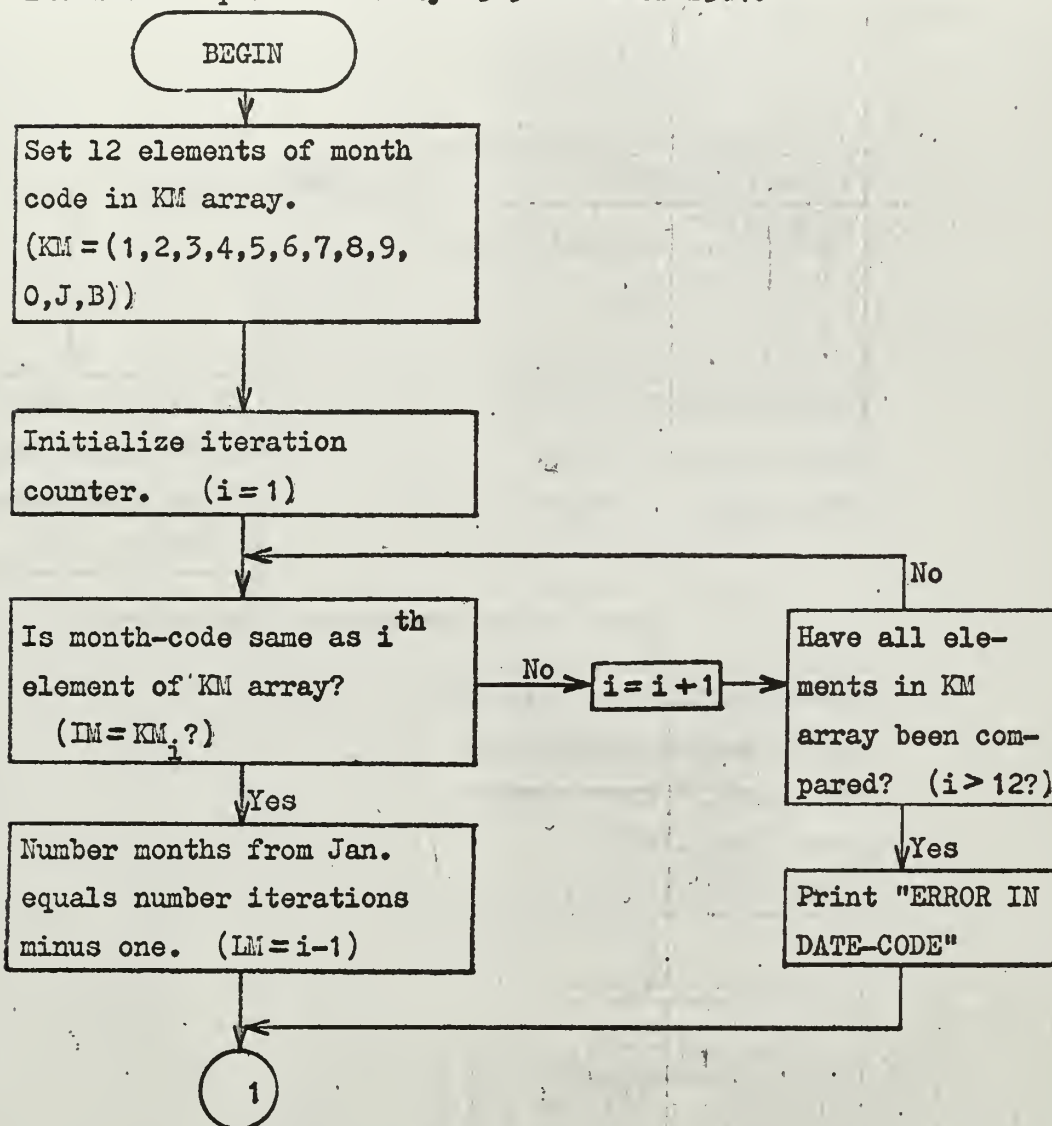
TABLE OF VARIABLES AND CONSTANTS USED IN FUNCTION IDA

- | | | |
|----|-------|---------------------------------------|
| 1. | IM | Alpha-numeric month code. |
| 2. | IY | Numeric year code. |
| 3. | KM(I) | Table of month codes for decoding IM. |
| 4. | LM | No. of months from January. |
| 5. | LY | No. of years from 1965. |
| 6. | IDA | No. of months from January 1965. |

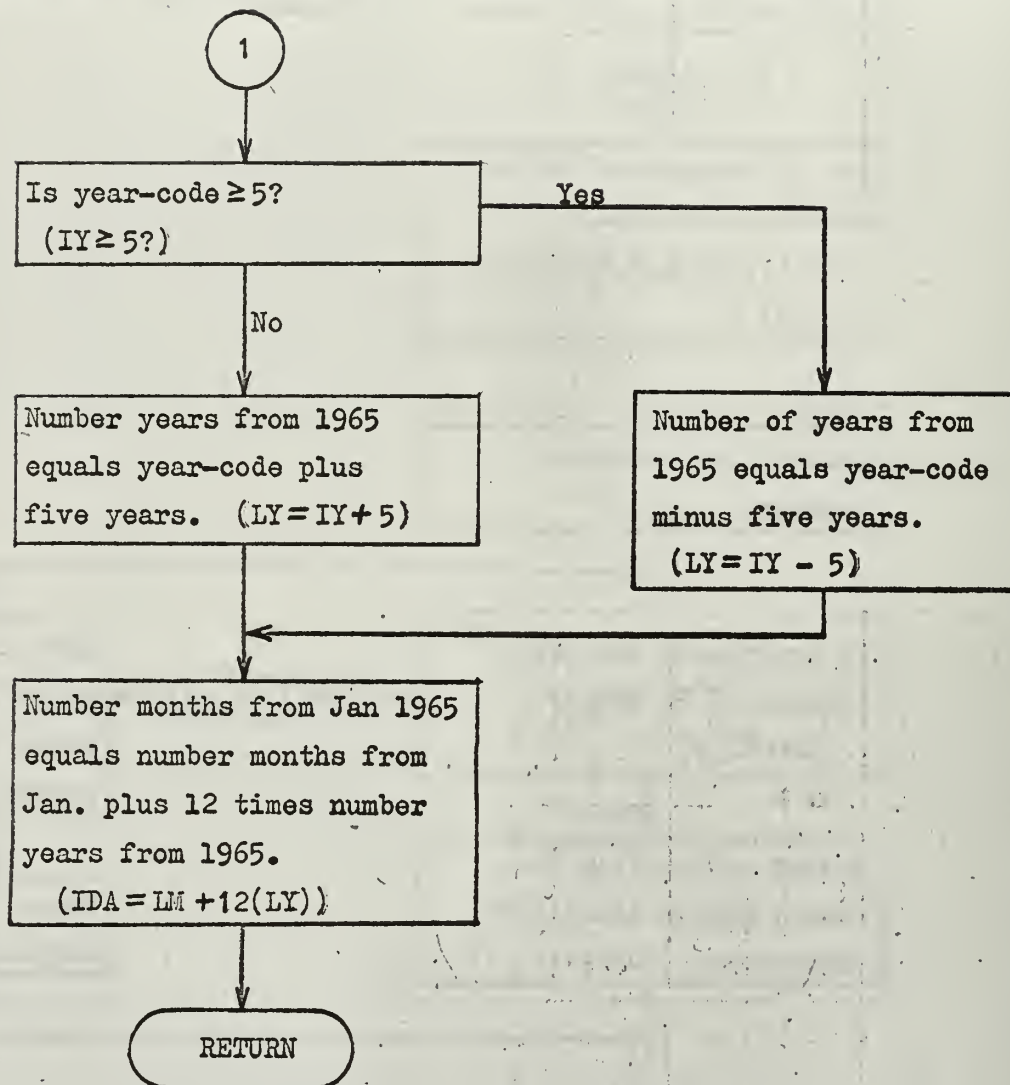
APPENDIX D

Plain-language Flow-Chart for Function Subprogram IDA

FUNCTION IDA converts month-year code (IM,IY) to number of months from January 1965. All date codes are assumed to be included in period January 1965-December 1974.



APPENDIX D



APPENDIX D

```

0144      FUNCTION IDA(IM,IY)
0145
0146      C THIS SUBPROGRAM CONVERTS MO-YR CODE TO NO. OF MONTHS FROM JAN 65
0147      C
0148      DIMENSION KM(12)
0149      DATA(KM=1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H0,1HJ,1HB)
0150      DO 1 I=1,12
0151      IF(IM.EQ. KM(I))2,1
0152      2 LM=I-1
0153      GO TO 3
0154      1 CONTINUE
0155      PRINT 9,IM,IY
0156      3 IF(IY-5)4,5,5
0157      4 LY=IY+5
0158      GO TO 6
0159      5 LY=IY-5
0160      6 IDA=LM+12*LY
0161      9 FORMAT(18H IDA ERROR IM,IY= A1,I1)
0162      RETURN
0163      END

```

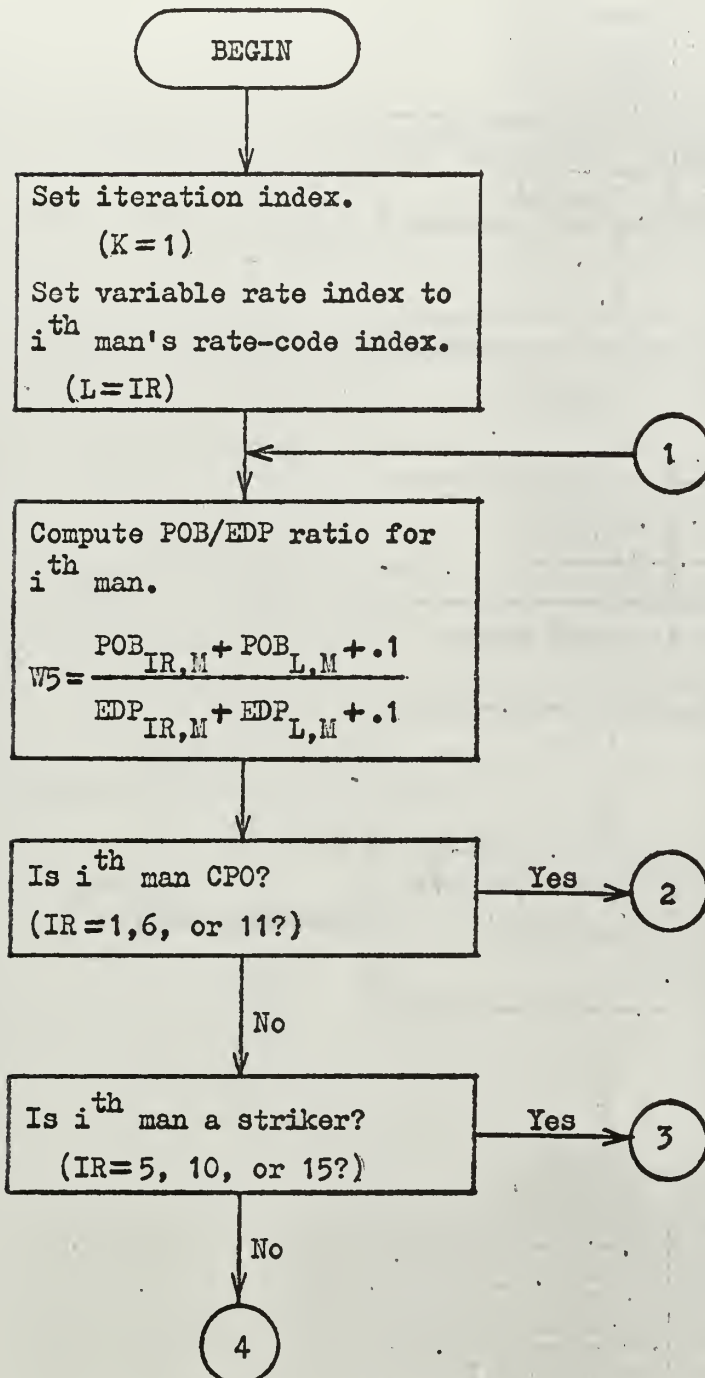

APPENDIX D

TABLE OF VARIABLES AND CONSTANTS USED IN SUBROUTINE RATIO

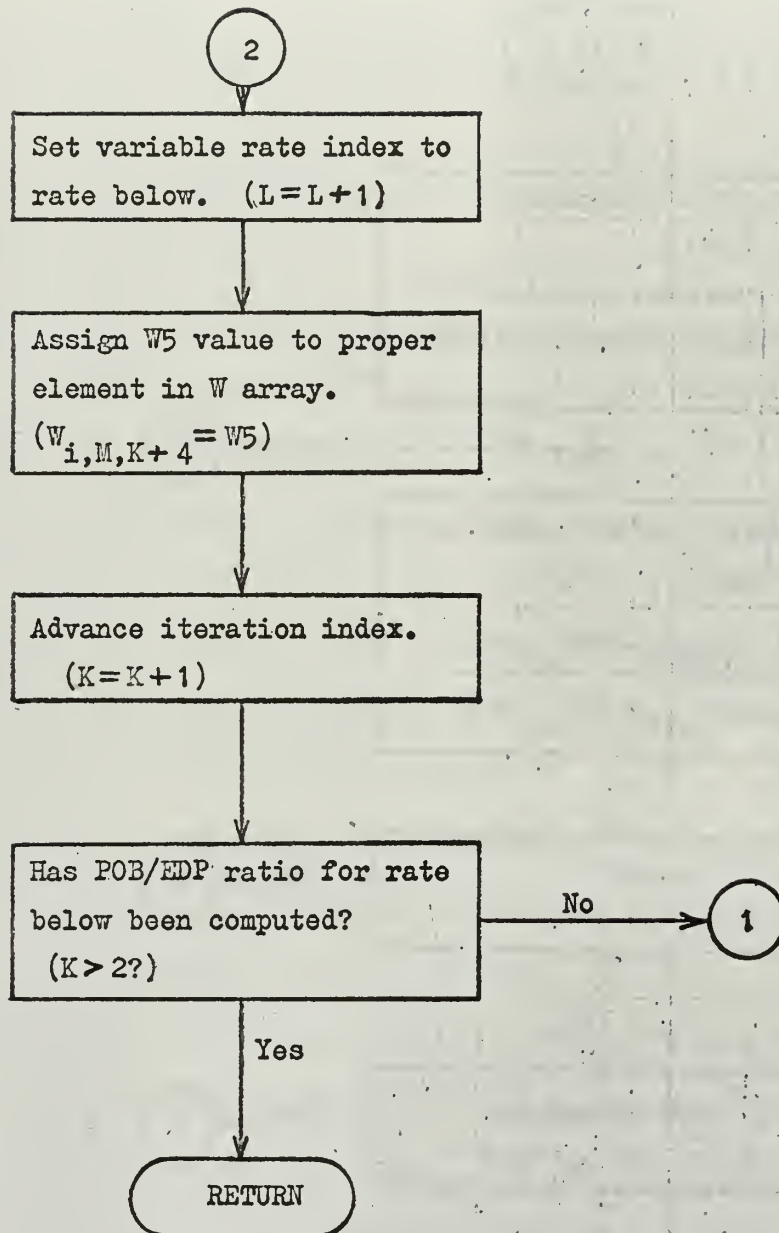
- | | | |
|----|--------|---|
| 1. | S(L,M) | EDP-POB values for ship M. Same as SA(L,M). |
| 2. | XE | EDP for rate or rate above or rate below that of I th man on M th ship. |
| 3. | XEE | EDP for rate of I th man on M th ship + .1. |
| 4. | XP | POB for rate or rate above or rate below that of I th man on M th ship. |
| 5. | XPP | POB + .1 for rate of I th man on M th ship. |
| 6. | W5 | Dummy variable for temporary storage of (POB)/(EDP) ratio. |
| 7. | L | Subscript corresponding to rate code index for I th man. Varies to include rate above and/or below values. |
| 8. | K | Iteration counter used to place W5 value in proper element of W _{ijk} array and to terminate ratio process. |

APPENDIX D

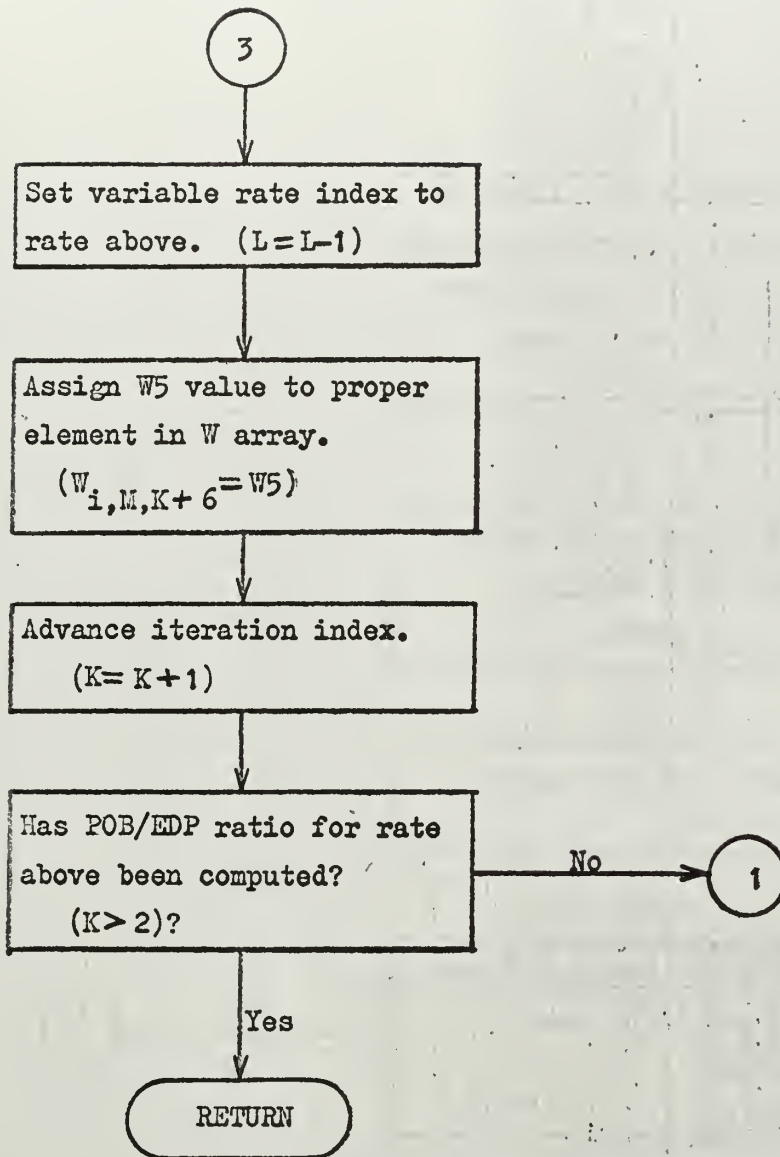
Plain-language Flow-chart for Subroutine Subprogram RATIO



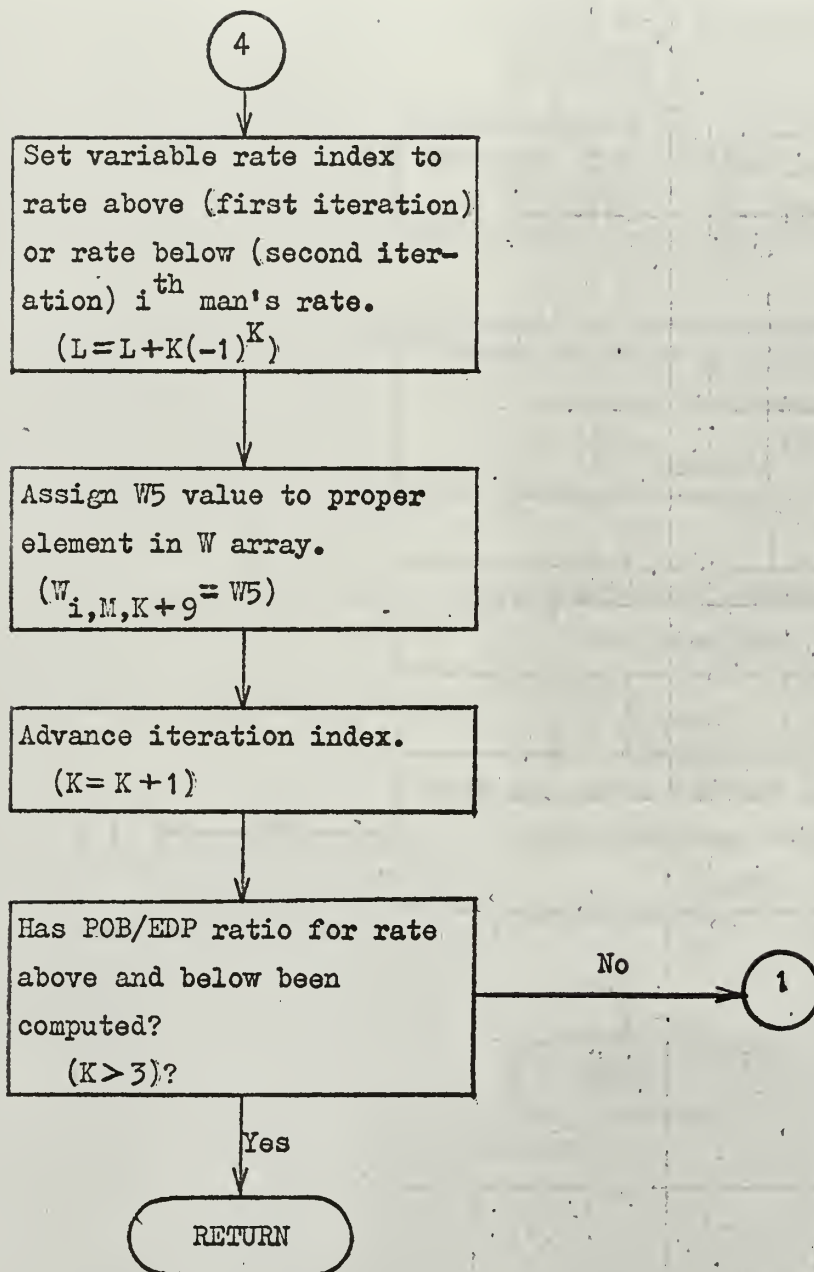
APPENDIX D



APPENDIX D



APPENDIX D



APPENDIX D

```

0164 SUBROUTINE RATIO(IR,I,M)
0165
0166 C FOR MANS RATE, COMPUTE POB/EDP RATIO FOR ALL SHIPS.
0167 C THEN DO SAME FOR RATE ABOVE AND/OR BELOW.
0168
0169 COMMON S,W,MA,KS,U,NSHIP
0170 DIMENSION S(30,16),W(50,16,15),MA(50,15),KS(8,16),U(50,16)
0171 K=1 $ L=IR
0172 8 XE=S(L,M) $ XP= S(L+15,M)
0173 XEE=S(IR,M)+.1 $ XPP=S(IR+15,M)+.1
0174 W5 =(XP+XPP)/(XE+XEE)
0175
0176 21 GO TO (5,6,6,6,7,5,6,6,6,7,5,6,6,6,7)IR
0177
0178 5 L=L+1 $ W(I,M,K+4)= W5 $ K=K+1
0179 IF(K-2)8,8,9
0180 HAS COMPUTED CPO,NOW COMPUTES PO1
0181
0182 6 L=L+K*(-1)**K$ W(I,M,K+6)=W5 $ K=K+1
0183 IF(K-3)8,8,9
0184 HAS COMPUTED PO1 OR PO2 OR PO3, NOW COMPUTE RATE ABOVE AND BELOW
0185
0186 7 L=L-1 $ W(I,M,K+9)=W5$ K=K+1
0187 IF(K-2)8,8,9
0188 HAS COMPUTED SN, NOW COMPUTE PO3
0189
0190 9 CONTINUE
0191 RETURN
0192 END

```

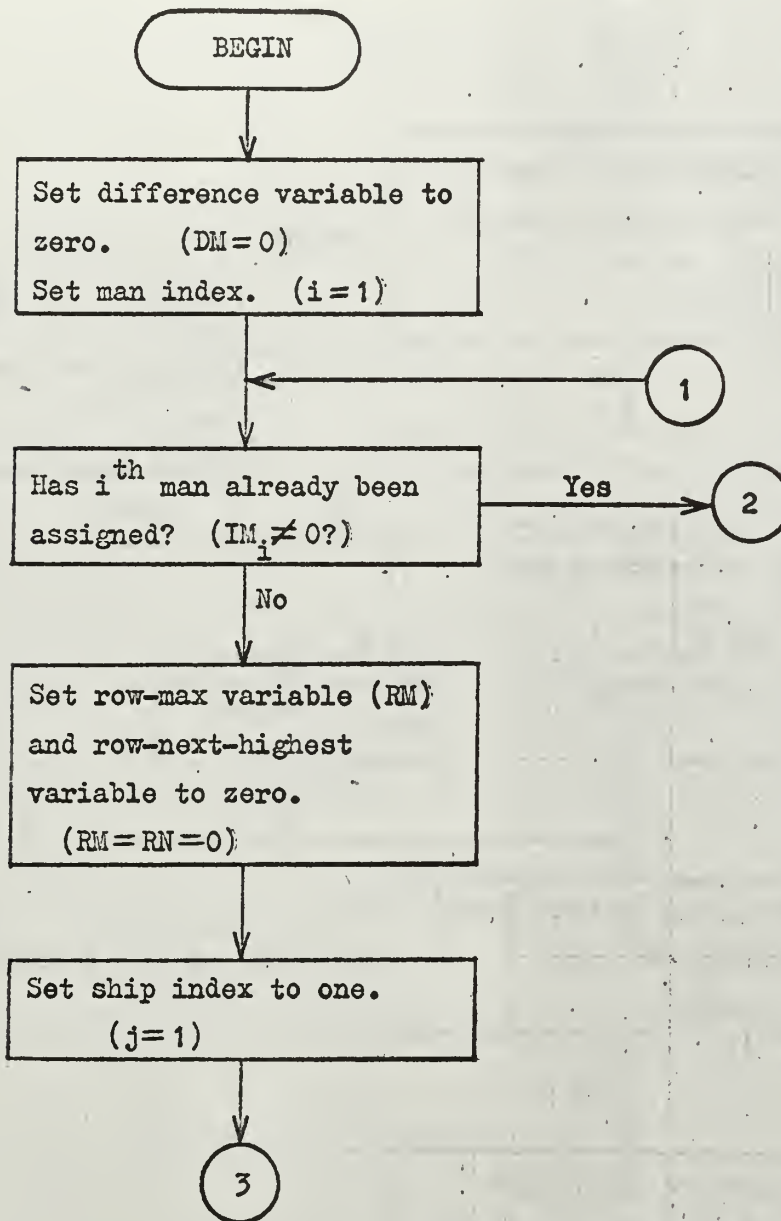
APPENDIX D

TABLE OF VARIABLES AND CONSTANTS USED IN SUBROUTINE ASSIGN

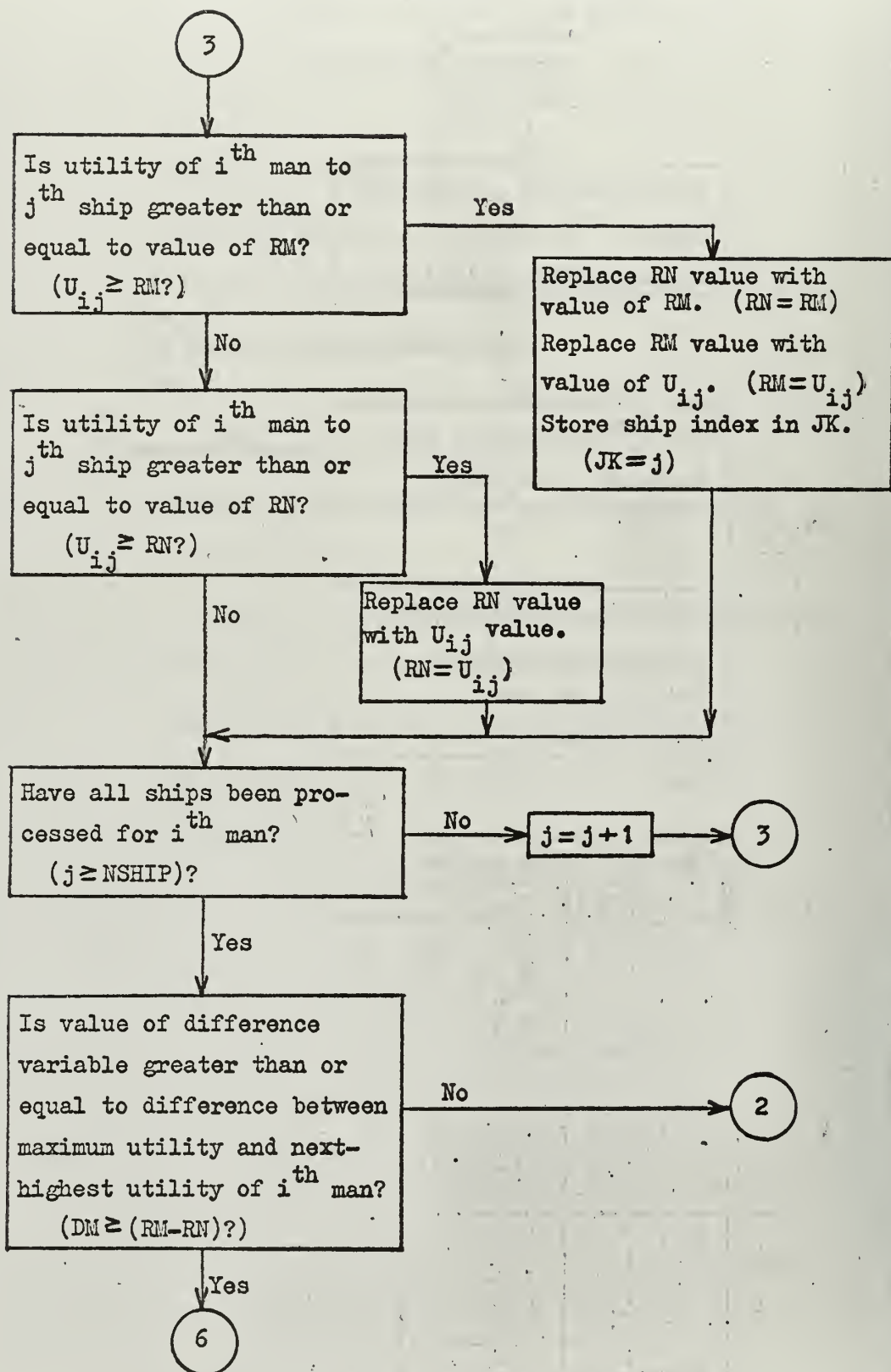
- | | | |
|----|----|---|
| 1. | RM | Maximum utility of I^{th} man. |
| 2. | RN | Next highest utility of I^{th} man. |
| 3. | DM | Maximum difference between RM and RN for all unassigned men. |
| 4. | JK | Temporary storage for number of ship which has highest utility for I^{th} man. |
| 5. | LM | Number of man (utility array row) which is to be assigned. |
| 6. | JS | Number of ship (utility array column) to which LM^{th} man is to be assigned. |
| 7. | IT | Dummy variable which defines column in POB array to be corrected when man is assigned. |

APPENDIX D

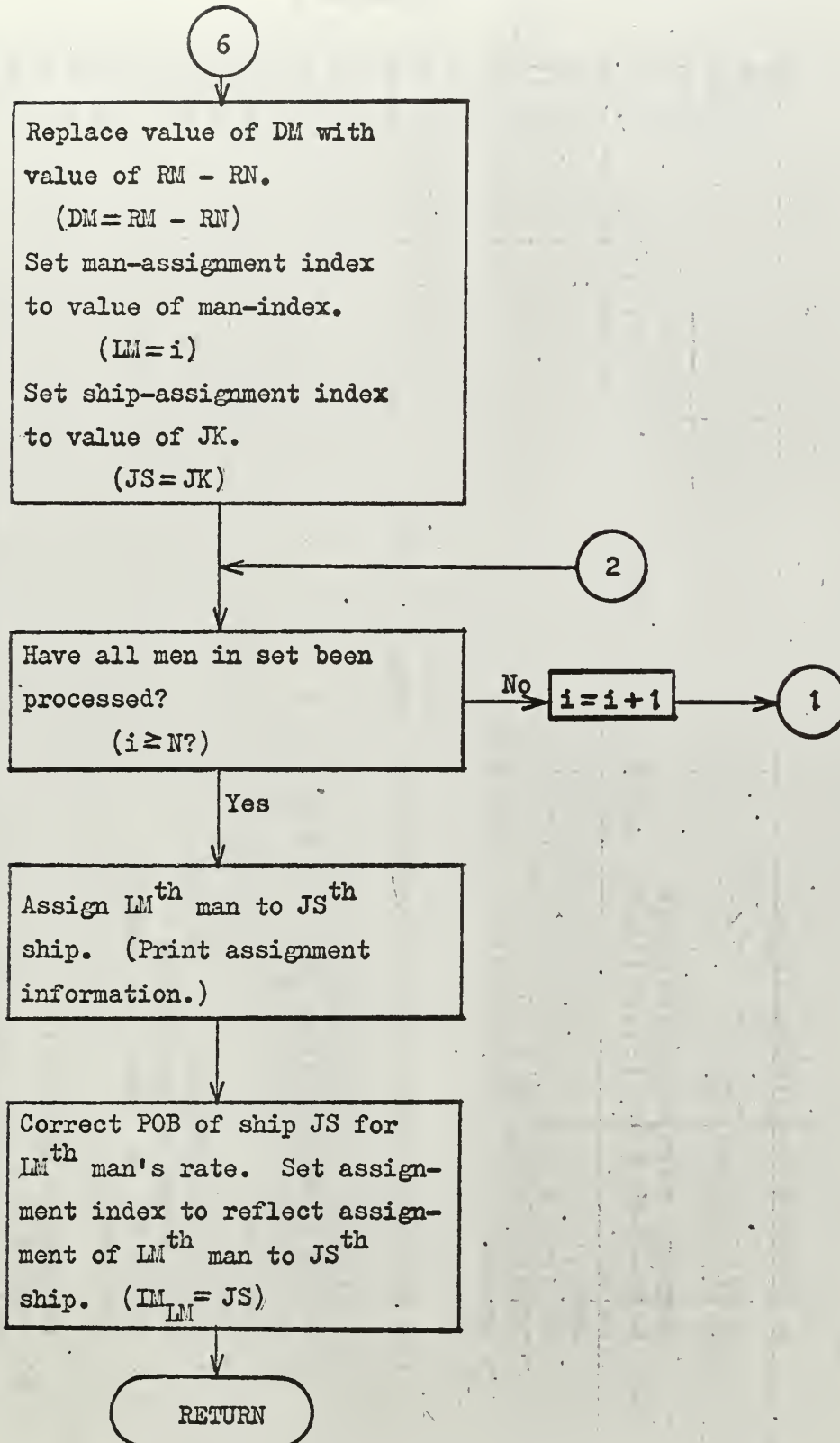
Plain-language Flow-chart for Subprogram Subroutine ASSIGN



APPENDIX D



APPENDIX D



APPENDIX D

```

0193 SUBROUTINE ASSIGN(N,IR,IM,LM)
0194 C
0195 C MODIFIED VAM METHOD
0196 C
0197 COMMON SA,W,MA,KS,U,NSHIP
0198 DIMENSION KS(8,16),SA(30,16),W(50,16,15),MA(50,16),U(50,16),IR(N),
0199 1IM(N)
0200 DM=0.
0201 DO 72 I = 1,N
0202 IF(IM(I))5,5,72
0203 5 RM=RN=0.
0204 DO 3 J=1,NSHIP
0205 C
0206 C FIND MAX U IN EACH ROW AND DIFFERENCE BETWEEN SECOND HIGHEST U
0207 C
0208 IF(U(I,J) - RM)6,2,2
0209 2 RN=RM $ RM=U(I,J) $ JK =J $ GO TO 3
0210 6 IF(U(I,J) - RN)3,4,4
0211 4 RN=U(I,J)
0212 3 CONTINUE
0213 C FIND MAX DIFFERENCE
0214 IF((RM-RN) - DM)72,8,8
0215 8 DM=RM-RN $ LM=I $ JS=JK
0216 72 CONTINUE
0217 C
0218 IF(IM(LM))31,30,31
0219 30 CONTINUE
0220 PRINT 14,MA(LM,2),MA(LM,4),KS(1,JS),KS(2,JS),LM,JS, U(LM,JS)

```

```

C      IM(LM)=JS
C      IT=IR(LM)+15
C      UPDATE POB-6
C
      SA(IT,JS)=SA(IT,JS)+1.
      PRINT 111,MA(LM,2),MA(LM,4)
      DO 16 J = 1,NSHIP
16      PRINT 15,LM,J,(W(LM,J,K),K=1,11),U(LM,J)
14      FORMAT(1H0,5X8H ASSIGN ,A8,1X,A4,4H TO ,2A8, 5X,2I4,F10.3)
15      FORMAT(2I3,4F5.0,7F6.2,F9.2)
111     FORMAT(1H0,5X,25H W VECTOR AND UTILITY OF ,A8,1X,A4,
              114H FOR ALL SHIPS)
31      CONTINUE
      RETURN
      END

```

0221
0222
0223
0224
0225
0226
0227
0228
0229
0230
0231
0232
0233
0234
0235
0236

APPENDIX D

Modification to Program AUTAM* for Row-Column Method of Assignment

```
      JA = 1
      DO 90 I2=1,N
C
C   EXECUTE THIS LOOP FOR ASSIGNMENT
C
      DO 88 I=1,N
      GR(I)=0.
      IF(IM(I))86,86,88
86   DO 189 J=1,NSHIP
      CALL RATIO(IR(I),I,J)
      U(I,J)=A(1)
      DO 189 K=1,11
      U(I,J)=U(I,J)+W(I,J,K)*A(K+1)
189  CONTINUE
      88 CONTINUE
      CALL ASSIGN(N,IR,IM,JA,IK)
```

*Statements shown above replace card numbers 0100-0115
(inclusive) in Program AUTAM.

APPENDIX D

Modification to Program AUTAM* for Marginal Utility Computation

```

      SU=SRU=TN=0.
      DO 168 I=1,N
      IF(IM(I)-99)171,168,168
171  J = IM(I)
      IRA=IR(I)+15
      SA(IRA,J)=SA(IRA,J)-1.
      CALL RATIO(IR(I),I,J)
      T=A(1)
      DO 188 K=1,11
      GR(K)=GR(K)+W(I,J,K)
188  T=T+W(I,J,K)*A(K+1)
      SU=SU+U(I,J)
      SRU=SRU+T
      SA(IRA,J)=SA(IRA,J)+1.
      PRINT 170,I,J,U(I,J),T,IK(I),(W(I,J,K),K=1,11)
      TN=TN+1.
168  CONTINUE
      PRINT 172,SU,SRU,(GR(K),K=1,11)
      SU=SU/TN    $    SRU=SRU/TN
      DO 173 K=1,11
173  GR(K)=GR(K)/TN
      PRINT 172,SU,SRU,(GR(K),K=1,11)
170  FORMAT(1H ,2I5,2F10.3,5X,I3,2X,11F7.2)
172  FORMAT(11X,2F10.3,10X,11F7.3)

```

*The above statements follow card number 0124 in Program AUTAM.

APPENDIX E

1. Program Listing for Row-Max Method

```

SUBROUTINE ASSIGN(N,IR,IM,LM)
C ASSIGN TO MAX UTILITY IN EACH ROW SEQUENTIALLY
C
COMMON SA,W,MA,KS,U,NSHIP
DIMENSION KS(8,16),SA(30,16),W(50,15),MA(50,15),U(50,16),IR(N),
1IM(N),UM(50),DIFM(50),JK(50)
UMAX = -10.
DO 74 I = 1,N
IF(IM(I))5,5,74
5 DO 72 J = 1,NSHIP
73 UMAX = U(I,J)73,73,72
LM=1 $ JS = J
72 CONTINUE
GO TO 7
74 CONTINUE
7 CONTINUE
30 IF(IM(LM))31,30,31
PRINT 14, MA(LM,2),MA(LM,4),KS(1,JS),KS(2,JS),LM,JS, U(LM,JS)
IM(LM)=JS
IT=IR(LM)+15
C UPDATE PCB-6
C
SA(IT,JS)=SA(IT,JS)+1.
PRINT 111,MA(LM,2),MA(LM,4)
DO 16 J = 1,NSHIP
16 PRINT 15,LM,J,LW(LM,J,K),K=1,11),U(LM,J)
14 FORMAT(1H0,5X8H ASSIGN ,A8,1X,A4,4H TO ,2A8, 5X,2I4,F10.3)
15 FORMAT(2I3,4F5.0,7F6.2,F9.2)
111 FORMAT(1H0,5X,25H W VECTOR AND UTILITY OF ,A8,1X,A4,
111 14H FOR ALL SHIPS)
31 CONTINUE
RETURN
END

```


2. Program Listing for Array-Max Method

```

C      SUBROUTINE ASSIGN(N, IR, IM, LM)
C      ARRAY MAX METHOD
COMMON SA, W, MA, KS, U, NSHIP
DIMENSION KS(8,16), SA(30,16), W(50,15,15), MA(50,15), U(50,16), IR(N),
1IM(N), UM(50), DIFM(50), JK(50)
UMAX = -10.
DO 74 I = 1, N
  IF(IM(I)) 5, 5, 74
5 DO 72 J = 1, NSHIP
73 IF(UMAX - U(I, J)) 73, 73, 72
72 UMAX = U(I, J)
74 LM = I $ JS = J
72 CONTINUE
74 IF(IM(LM)) 31, 30, 31
30 CONTINUE
PRINT 14, MA(LM, 2), MA(LM, 4), KS(1, JS), KS(2, JS), LM, JS, U(LM, JS)
IM(LM) = JS
PRINT 14, MA(LM, 2), MA(LM, 4), KS(1, JS), KS(2, JS), LM, JS, U(LM, JS)
IM(LM) = JS
IT = IR(LM) + 15
C      UPDATE PCB-6
C
SA(IT, JS) = SA(IT, JS) + 1.
PRINT 11, MA(LM, 2), MA(LM, 4)
DO 16 J = 1, NSHIP
16 PRINT 15, LM, J, (W(LM, J, K), K=1, 11), U(LM, J)
14 FORMAT(1H0, 5X8H ASSIGN, A8, 1X, A4, 4H TO, 2A8, 5X, 2I4, F10.3)
15 FORMAT(2I3, 4F5.0, 7F6.2, F9.2)
111 FORMAT(1H0, 5X, 25H W VECTOR AND UTILITY OF, A8, 1X, A4,
111 114H FOR ALL SHIPS)
31 CONTINUE
RETURN
END

```

APPENDIX E

3. Program Listing for Row-Column-Max Method

C	ROW	SUBROUTINE ASSIGN(N,IR,IM,JA,IK)	0445
		-COLUMN MAX METHOD	0446
		COMMON SA,W,MA,KS,U,NSHIP	0449
		DIMENSION KS(8,16),SA(30,16),W(50,16),MA(50,15),U(50,16),IR(N),	0450
		IM(N),IK(50)	0451
		DO 72 L=1,NSHIP	0452
		UMAX = -10.	0453
		DO 74 I=1,N	0454
		IF(IM(I)) 5,5,74	0455
	5	IF(UMAX - U(I,L)) 73,74,74	0456
	73	UMAX = U(I,L)	0457
	74	LM = I \$ JS = L	0458
		CONTINUE	0459
		DO 75 M=1,NSHIP	0460
		IF(UMAX - U(LM,M)) 72,75,75	0461
	75	CONTINUE	0462
	30	IF(IM(LM)) 31,30,31	0466
		CONTINUE	
		IM(LM)=JS \$ IK(LM) = JA \$ JA=JA+1	0481
		PRINT 14,MA(LM,2),MA(LM,4),KS(1,JS),KS(2,JS),LM,JS, U(LM,JS)	0220
		IT=IR(LM)+15	0222
C	UPDATE	POB-6	0223
C			0224
		SA(IT,JS)=SA(IT,JS)+1.	0225
		PRINT 11,MA(LM,2),MA(LM,4)	0226
		DO 16 J=1,NSHIP	0227
	16	PRINT 15,LM,J,(W(LM,J,K),K=1,11),U(-M,J)	0228
	14	FORMAT(1H0,5X8H ASSIGN ,A8,1X,A4,4H TO ,2A8, 5X,2I4,F10.3)	0229
	15	FORMAT(2I3,4F5.0,7F6.2,F9.2)	0230
	111	FORMAT(1H0,5X,25H W VECTOR AND UTILITY OF ,A8,1X,A4,	0231
	111	14H FOR ALL SHIPS)	0232
	31	CONTINUE	0233
		RETURN	0234
		END	0235
			0236

4. Program Listing for Decision-Index Method

```

C      SUBROUTINE ASSIGN(N,IR,IM,LM)
C      DECISION INDEX METHOD
C
COMMON  SA,W,MA,KS,U,NSHIP
DIMENSION KS(8,16),SA(30,16),W(50,15,15),MA(50,15),U(50,16),IR(N),
1IM(N),UM(50),DIFM(50),JK(50)
DIMENSION D(50,16),CR(50),CC(16)
IN=0
DO 3 I=1,N
  IF(IM(I))5,5,3
5  CR(I)=0.
  IN=IN+1.
DO 2 J=1,NSHIP
2  CR(I)=CR(I)+U(I,J)
3  CONTINUE
DO 4 J=1,NSHIP
  CC(J)=0.
DO 4 I=1,N
  IF(IM(I))6,6,4
6  CC(J)=CC(J)+U(I,J)
4  CONTINUE
DM=-10000.
DO 7 I=1,N
  IF(IM(I))9,9,7
9  DO 7 J=1,NSHIP
    IF(IN.EQ.1.)12,11
11  D(I,J)=IN*U(I,J)-CR(I)-CC(J)
    GO TO 13
12  D(I,J)=U(I,J)
10  IF(D(I,J)-DM)7,7,8
8  DM=D(I,J) $ JS=J $ LM=I
7  CONTINUE
  IF(IM(LM))31,30,31

```

3
 03245
 03256
 03267
 03278
 03289
 0330
 0331
 03323
 03334
 03345
 03356
 03367
 03378
 03389
 0339
 0340
 0341
 0342
 0343
 03445
 0346
 0347
 0348
 0349
 0350
 0351
 03522
 0353
 0354
 0355

APPENDIX E

30	CONTINUE		0263
	PRINT 14, MA(LM,2), MA(LM,4), KS(1,JS), KS(2,JS), LM, JS, U(LM,JS)		0269
	IM(LM)=JS		0220
	PRINT 14, MA(LM,2), MA(LM,4), KS(1,JS), KS(2,JS), LM, JS, U(LM,JS)		0221
	IM(LM)=JS		0222
	IT=IR(LM)+15		0223
C	UPDATE POB-6		0224
C			0225
	SA(IT,JS)=SA(IT,JS)+1.		0226
	PRINT 111, MA(LM,2), MA(LM,4)		0227
	DO 16 J = 1, NSHIP		0228
	16 PRINT 15, LM, J, (W(LM,J,K), K=1,11), U(LM,J)		0229
	14 FORMAT(1H0,5X8H ASSIGN ,A8,1X,A4,4H TO ,2A8, 5X,2I4,F10.3)		0230
	15 FORMAT(2I3,4F5.0,7F6.2,F9.2)		0231
	111 FORMAT(1H0,5X,25H W VECTOR AND JTILITY OF ,A8,1X,A4,		0232
	114H FOR ALL SHIPS)		0233
	31 CONTINUE		0234
	RETURN		0235
	END		0236

APPENDIX F

** BEGIN RUN FROM DATA SET 1 **

MEN TO BE ASSIGNED

1	MCCRE	KEN	BM1	MCBASE	CP	LEJUN	C33	TU	36	ACSS	87	HP	PI
2	MAY	CHAR	SM2	NAVSTA	SCIEACH	OTH	C72	TU	35	EACSS	09	HP	YX
3	TAYLOR	W C	BM1	COMSTA	SFRISCO	C76		TU	36	EACSS	98	HP	XV
4	THOMPSON	K H	BM3	NAVSTA	CP	NCC	31	TU	05	ACSS	99	HP	ZW
5	ANDERSON	W	BM3	USNH	SAN	DI	EGO	TU	06	ACSS	78	HP	Y N
6	HADLEY	WEL	BM3	TAP114	GEN	WM	MITCH	TU	35	ACSS	77	HP	NW
7	SPENCER	WALD	BM3	NAVSTA	NCR	VAH	C32	TU	06	ACSS	77	HP	Y N
8	DUDLEY	CCRL	BM3	NS	LBEACH	OTH		TU	35	ACSS	77	HP	CD
9	VEGAN	ECWA	SM2	LSD	QUON	ANN	PT	TU	05	ACSS	77	HP	VV
10	BARAN	SENOR	BM1	OTS	PAS	GEN	WM	TU	46	ACSS	77	HP	22
11	VILLAS	I L	BM2	TAP114	ADAK	WM	MITCH	TU	16	ACSS	77	HP	UY
12	DUNGLAN	W	BM3	NAVSTA	GEN	OTH		TU	65	ACSS	77	HP	
13	ENGLE	W	BM3	NS	LBEACH	GEN	OTH	TU	05	ACSS	77	HP	
14	STUART	W	BM3	NS	ANDREW	RI	C85	TU	36	ACSS	77	HP	XFE
15	ABRAM	WICZ	BM3	NS	WASH	ING	TCN	TU	05	ACSS	77	HP	CEE
16	PUGH	TAK	BM3	NS	WASH	ING	TCN	TU	36	ACSS	77	HP	YZ
17	WHIT	TAK	BM3	NS	WASH	ING	TCN	TU	05	ACSS	77	HP	PL
18	GREAR	IGR	BM3	NS	WASH	ING	TCN	TU	36	ACSS	77	HP	XY
19	JAMES	IGR	BM3	NS	WASH	ING	TCN	TU	05	ACSS	77	HP	SW
20	TRIGG	IGR	BM3	NS	WASH	ING	TCN	TU	36	ACSS	77	HP	VV
21	HUGHES	IGR	BM3	NS	WASH	ING	TCN	TU	05	ACSS	77	HP	WM
22	WING	IGR	BM3	NS	WASH	ING	TCN	TU	36	ACSS	77	HP	RT
23	OLING	IGR	BM3	NS	WASH	ING	TCN	TU	05	ACSS	77	HP	
24			BM3	NS	WASH	ING	TCN	TU	36	ACSS	77	HP	
25			BM3	NS	WASH	ING	TCN	TU	05	ACSS	77	HP	
26			BM3	NS	WASH	ING	TCN	TU	36	ACSS	77	HP	
27			BM3	NS	WASH	ING	TCN	TU	05	ACSS	77	HP	
28			BM3	NS	WASH	ING	TCN	TU	36	ACSS	77	HP	
29			BM3	NS	WASH	ING	TCN	TU	05	ACSS	77	HP	
30			BM3	NS	WASH	ING	TCN	TU	36	ACSS	77	HP	

APPENDIX F

WEIGHTS USED IN ASSIGNMENT

A(1)=10.000
 A(2)= .260
 A(3)= -.300
 A(4)= 1.410
 A(5)= .330
 A(6)= -3.500
 A(7)= -1.590
 A(8)= -2.270
 A(9)= -1.940
 A(10)= -.880
 A(11)= -3.140
 A(12)= -1.820

SHIPS TO BE ASSIGNED TO

1	USS GCLF	05	66	Y	7
2	USS KILC	85	36	X	11
3	USS ECHC	96	47	W	5
4	USS CSCAR	85	66	Y	15
5	USS LIMA	J6	67	X	12
6	USS JULIET	16	76	X	10
7	USS HCTEL	56	37	Y	8
8	USS FOXTROT	85	96	W	6
9	USS DELTA	45	85	Y	4
10	USS BRAVO	J5	86	W	2

APPENDIX F

(BEFORE ASSIGNMENT)
EDP/POB

EM		CM					SM				
2	6	18	32	1	0	0	1	1	1	1	E 7 1P 7
1	4	8	16	9	0	0	1	1	1	1	E 11 1P 11
2	6	15	19	0	0	0	1	1	1	1	E 5 1P 5
1	2	4	6	0	0	0	1	0	0	0	E 15 1P 15
1	4	8	16	0	0	0	1	1	1	1	E 12 1P 12
1	4	8	16	0	0	0	1	1	1	1	E 10 1P 10
2	6	18	32	1	0	0	1	1	1	1	E 8 1P 8
2	6	18	31	1	0	0	1	1	1	1	E 6 1P 6
1	5	8	13	0	0	0	1	1	1	1	E 4 1P 4
1	5	8	13	0	0	0	1	1	1	1	E 2 1P 2

APPENDIX F

ASSIGN KERSCN J BM1 TO USS DELTA 27 9 8.022

W	VECTOR	AND	UTILITY	OF	KERSON J BM1	FOR ALL SHIPS	27	9	8.022
1	0	0	0	0	0	75	83	0	0
2	0	0	0	0	0	1:20	83	0	0
3	0	0	0	0	0	1:00	91	0	0
4	0	0	0	0	0	1:08	67	0	0
5	0	0	0	0	0	1:00	25	0	0
6	0	0	0	0	0	1:00	25	0	0
7	0	0	0	0	0	1:12	56	0	0
8	0	0	0	0	0	1:30	37	0	0
9	0	0	0	0	0	1:41	56	0	0
10	0	0	0	0	0	1:80	70	0	0
27	0	0	0	0	0	84	62	0	0
27	0	0	0	0	0	67	1:00	0	0
27	0	0	0	0	0	80	0	0	0

ASSIGN GARRIDO CM1 TO USS OSCAR 23 4 10.746

W	VECTOR	AND	UTILITY	OF	GARRIDO CM1	FOR ALL SHIPS	23	4	10.746
1	0	0	0	0	0	09	52	0	0
2	0	0	0	0	0	1:00	1:52	0	0
3	0	0	0	0	0	1:00	09	0	0
4	0	0	0	0	0	1:05	09	0	0
5	0	0	0	0	0	1:05	09	0	0
6	0	0	0	0	0	1:05	48	0	0
7	0	0	0	0	0	1:91	48	0	0
8	0	0	0	0	0	1:00	00	0	0
9	0	0	0	0	0	1:00	52	0	0
10	0	0	0	0	0	1:00	0	0	0
23	0	0	0	0	0	09	52	0	0
23	0	0	0	0	0	1:00	1:52	0	0
23	0	0	0	0	0	1:00	09	0	0
23	0	0	0	0	0	1:05	09	0	0
23	0	0	0	0	0	1:05	48	0	0
23	0	0	0	0	0	1:91	48	0	0
23	0	0	0	0	0	1:00	00	0	0
23	0	0	0	0	0	1:00	52	0	0
23	0	0	0	0	0	1:00	0	0	0

ASSIGN WENGER R BM2 TO USS KILC 28 2 8.830

W	VECTOR	AND	UTILITY	OF	WENGER R BM2	FOR ALL SHIPS	28	2	8.830
1	0	0	0	0	0	83	80	0	0
2	0	0	0	0	0	83	54	0	0
3	0	0	0	0	0	87	79	0	0
4	0	0	0	0	0	87	90	0	0
5	0	0	0	0	0	1:25	96	0	0
6	0	0	0	0	0	1:25	75	0	0
7	0	0	0	0	0	1:25	92	0	0
8	0	0	0	0	0	1:25	72	0	0
9	0	0	0	0	0	1:25	67	0	0
10	0	0	0	0	0	1:25	1:05	0	0
28	0	0	0	0	0	83	80	0	0
28	0	0	0	0	0	83	54	0	0
28	0	0	0	0	0	87	79	0	0
28	0	0	0	0	0	87	90	0	0
28	0	0	0	0	0	1:25	96	0	0
28	0	0	0	0	0	1:25	75	0	0
28	0	0	0	0	0	1:25	92	0	0
28	0	0	0	0	0	1:25	72	0	0
28	0	0	0	0	0	1:25	67	0	0
28	0	0	0	0	0	1:25	1:05	0	0

APPENDIX F

(AFTER ASSIGNMENT)
EDP/PCB

BN		QM				SM				
2	6 6 18 32	1	0 0	1 3	4 4	1 1	1 1	2 5	0 0	E 7 1P 7
1	4 6 8 16	9	0 0	1 1	3 4	0 1	1 1	1 2	3 2	E 11 1P 11
2	6 6 15 19	2	0 0	1 1	4 8	1 0	1 1	1 4	1 0	E 5 1P 5
1	2 2 4 3	6	0 0	1 0	1 1	0 2	0 1	1 2	1 0	E 15 1P 15
1	4 4 8 16	9	0 0	1 1	3 4	0 0	1 1	1 3	3 0	E 12 1P 12
1	4 3 8 9	10	0 0	1 3	3 3	0 2	1 1	1 2	3 2	E 10 1P 10
2	6 8 18 22	3	0 0	1 2	4 3	1 3	1 0	2 3	2 0	E 8 1P 8
2	6 6 19 18	5	0 1	1 0	4 3	1 5	1 0	2 4	2 1	E 6 1P 6
1	5 4 8 7	13	0 1	1 1	3 4	0 0	0 1	1 3	2 1	E 4 1P 4
1	5 5 8 13	14	0 1	1 0	3 6	0 1	0 0	1 3	3 0	E 2 1P 2

INITIAL DISTRIBUTION LIST

	No. Copies
1. Defense Documentation Center Cameron Station Alexandria, Virginia 22314	20
2. Library U. S. Naval Postgraduate School Monterey, California	2
3. Assistant Professor Sam H. Parry (Thesis Advisor) Department of Operations Research U. S. Naval Postgraduate School Monterey, California	1
4. Chief of Naval Personnel (PERS-A3) Navy Department Washington, D. C. 20370	1
5. U. S. Naval Personnel Research Activity San Diego, California 92152	2
6. Lt. Russel N. Blatt, USN 2623 Whittier Avenue Midvale Manor Reading, Pennsylvania	1
7. Lt. Dudley E. Cass, USN SMC 2645 U. S. Naval Postgraduate School Monterey, California 93940	1

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Naval Postgraduate School Monterey, California 93940		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	
		2b. GROUP	
3. REPORT TITLE A MODEL FOR AUTOMATION OF PERSONNEL ASSIGNMENT			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Thesis			
5. AUTHOR(S) (Last name, first name, initial) Blatt, Russel N. and Cass, Dudley E.			
6. REPORT DATE October, 1966		7a. TOTAL NO. OF PAGES 111	7b. NO. OF REFS 18
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.		9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
10. AVAILABILITY/LIMITATION NOTICES Distribution of this document is unlimited			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY	
13. ABSTRACT This thesis demonstrates the feasibility of computerized assignment of Naval enlisted personnel to fleet units. A model is constructed for determining the utility of each man for each possible ship assignment. Then various methods of assignment are investigated to find one which maximizes the summed utilities of assignment. To illustrate its capabilities, the model is then applied to several sample sets of men and ships. The authors conclude that a model of this type should be implemented in the Navy's personnel distribution system.			

Security Classification

14.

KEY WORDS

Personnel Assignment
Utility
Computer Model

LINK A

LINK B

LINK C

ROLE

WT

ROLE

WT

ROLE

WT

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (*corporate author*) issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(a) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers (*either by the originator or by the sponsor*), also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those

imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

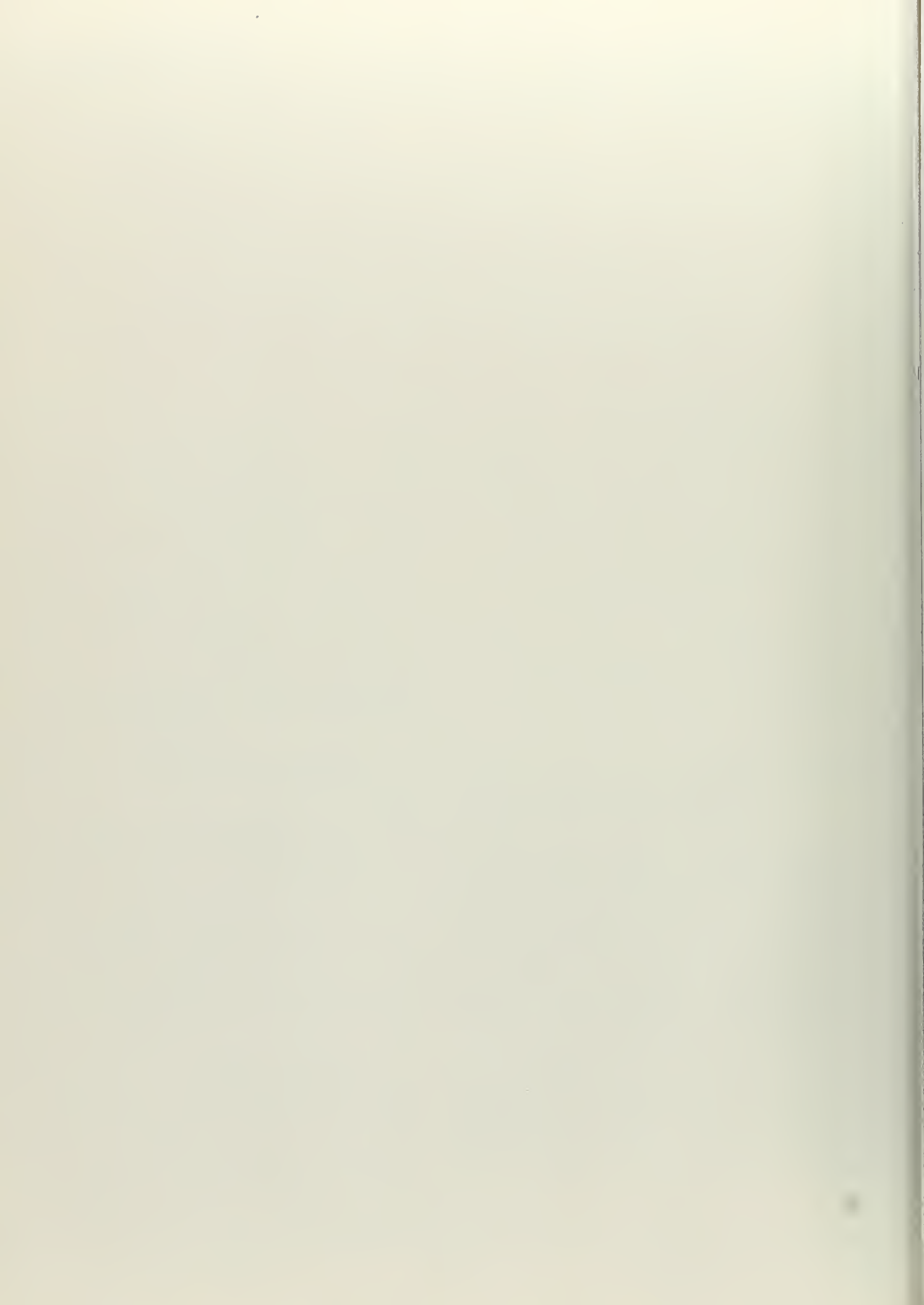
12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring (*paying for*) the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

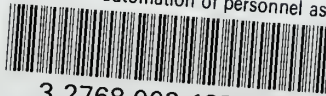
There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.



thesB555

A model for automation of personnel assi



3 2768 002 13553 5

DUDLEY KNOX LIBRARY